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ABSTRACT

This guide is the result of a consolidation of three separate, closely related dissertation studies designed to provide information for preparing a planning guide for drafting and design technology programs. One of the studies was of the Texas Junior College drafting and design curricula, another was of the buildings and equipment, and the third used an industrial survey to determine criteria for a program guide. The assumptions for formulating the suggested curriculum were that: (1) the course of study should be for students wishing to pursue a particular vocation, (2) the occupational needs of students are generated by employers, (3) the classification of occupations implies common knowledge and skill, (4) some occupations require unique knowledges and skills, (5) duplication of subject matter should be minimized, and (6) adequate equipment and facilities are necessary. The surveys of junior colleges were confined to those colleges with associate degree programs, and the industrial concerns were stratified according to areas of specialization, volume of employment, and regional location. The planning guide section of this document includes: (1) enrollment estimation, (2) suggested course of study, course outlines, and descriptions, (3) personal requirements, and (4) facilities and equipment. The data collection and analysis and the appendixes are available as VT 014 406 and VT 014 408 respectively. (GEB)

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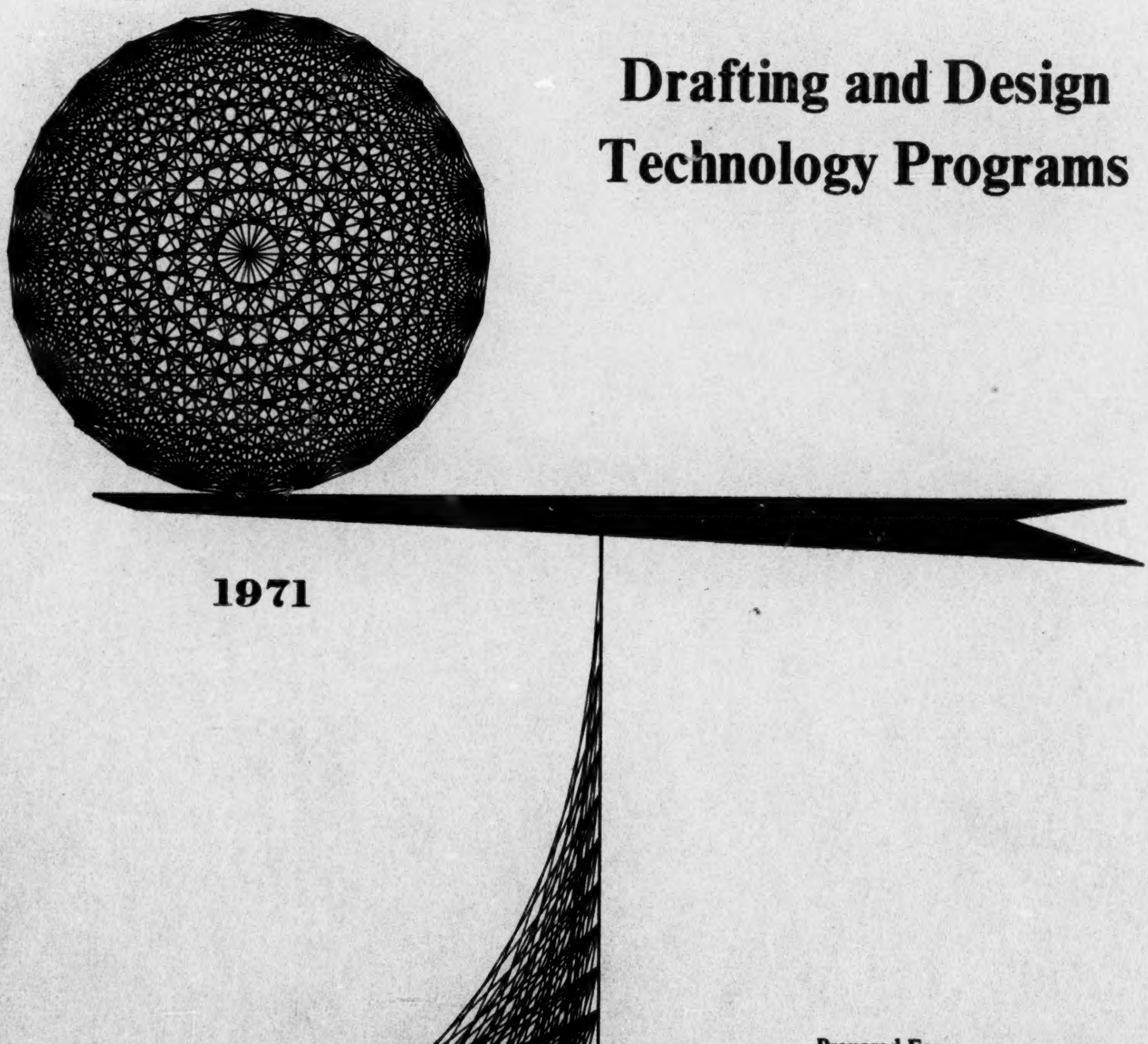
I, II

# A GUIDE FOR PLANNING

# Drafting and Design Technology Programs



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# A GUIDE
# FOR PLANNING
# DRAFTING AND DESIGN
# TECHNOLOGY PROGRAMS

by

Michael P. Guerard

Harry W. Walston

Gary H. Winegar

Prepared for

The Occupational Research Coordinating Unit

Texas Education Agency

Austin, Texas 78711

November, 1970

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2. Assignment of teachers and other staff without discrimination on the ground of race, color, or national origin.
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In addition to conducting reviews, Texas Education Agency staff representatives will check complaints of non-compliance made by citizens and will report their findings to the United States Commissioner of Education.

# Preface

This document represents the consolidation of three separate, but closely related studies, each of which led to a doctor's dissertation. These studies and their authors were:

A Study of Texas Junior College Drafting and Design Technology Curricula for Development of a Planning Guide. Michael P. Guerard, Texas A&M University.

An Industrial Survey to Determine Criteria for a Program Guide for Drafting and Design Technology in Texas Junior Colleges. Harry W. Walston, Texas A&M University.

A Study of Buildings and Equipment in Texas Junior College Drafting Technology Programs With Implications for a Planning Guide. Gary H. Winegar, Texas A&M University

The above studies were made under contract with the Texas Education Agency office of Post-Secondary Vocational Program Development, and this planning guide is the result of the collaboration of the three authors. Many individuals have contributed valuable information and guidance without which this document would not have been possible. Special thanks are extended to all the drafting teachers, professional draftsmen and supervisors who provided the data and recommendations upon which this planning guide is based. Appreciation is also expressed to state education agencies, many of whom provided samples of curriculum and planning guides for examination. The compilation and writing of this guide have been immeasurably aided by the guidance and suggestions of the Project Director, Dr. James H. Earle, Head, Department of Engineering Design Graphics, Texas A&M University. Valuable research assistance was provided by Mrs. Janet Davis, and the most difficult and exacting task of typing the final manuscript was performed admirably by Mrs. Ruth Hanson.

It is the authors' sincere wish that this guide will serve the needs of educators and curriculum planners in present and future programs in Drafting and Design Technology in Texas junior colleges.

Michael P. Guerard
Harry W. Walston
Gary H. Winegar

College Station, Texas
November, 1970

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# SECTION I

# DEVELOPMENTAL PROCEDURE

## Philosophy of Development

In formulating the suggested curriculum for Drafting and Design Technology, the following six premises were assumed:

1. A course of study should be tailored to meet the needs of students wishing to pursue a particular vocation.
2. The occupational needs of students are generated by employment opportunities provided by employers as a result of their own needs.
3. The classification of various occupations under a common category (e.g., technical occupations) implies a need for the acquisition of certain knowledges and skills common to those occupations.
4. Some areas of occupational specialty require the acquisition of unique knowledges and skills.
5. Duplication of subject matter and personnel effort should be minimized between courses in a curriculum, except where such duplication serves to reinforce or otherwise enhance the learning process.
6. Students, faculty, administrators and staff should have at least adequate equipment and facilities for conducting study and training effectively.

These premises constitute the rationale for designing a curriculum which consists of a core of basic courses common to all areas of design and drafting technology (premise #3), and a set of specialized courses which may be elected by the individual who wishes to pursue a particular specialty within the broader category (premise #4). Premises #1 and #2 are the bases for using data from a survey of Texas industries to assist in determining the areas of specialty in which employment opportunities exist, and the specific knowledges and skills required by those areas. These data indicate to a great extent what the content of specialty courses should be.

Premise #5 will be satisfied in part by the curriculum structure, specifically by the core of basic courses. These courses may be centrally administered without particular emphasis on any one specialty department.

As a result of a study of facilities and equipment in Drafting and Design Technology programs throughout the state, a section of the guide is concerned with recommendations for facilities and equipment needed for both basic and advanced, or specialty training of draftsmen, in accordance with premise #6.

## Junior College Survey

Two surveys were made of the state-supported junior colleges in Texas who offer associate degree programs in Drafting and Design Technology; one to obtain information about existing curricular structure of the programs, and the other to obtain data concerning physical facilities and equipment used.

Analysis of the present curricula in Drafting and Design Technology was aimed toward recognition of patterns of similarity or differences evident among the courses of study throughout the state, so that a "typical" curriculum, or portion thereof, might be developed as a "core" of common courses around which a complete, flexible program might be developed to suit individual student, school or industrial needs.

Not only the content of the programs, but also their length and sequence was investigated. The greatest emphasis was placed upon detailed topical breakdown of courses designated as "drafting" courses, since they constitute the major field of study. Courses in supporting areas were not topically analyzed, but merely selected and described according to a consensus of schools now including them in their Drafting and Design Technology programs.

Analysis of the drafting courses was made from data obtained from a questionnaire sent to drafting departments, and which requested an assessment of relative importance of topics listed under each course offered. Additional information was solicited concerning lecture-laboratory ratios, credit hours awarded per course, and the sequence (or semester) each was offered in the program. A more comprehensive discussion is found in Section III-A.

A survey of facilities available in Drafting and Design Technology programs throughout the state was made to gather information about those facilities which already exist, and also to obtain recommendations from drafting personnel concerning additions to or improvement of those facilities. The survey was conducted through mailed inventory forms and personal visits to each school, where photographs were taken of the facilities and equipment. In addition, light meter readings were taken to determine illumination levels available.

Facilities investigated including architectural characteristics, furnishings, instructors' offices, drafting equipment, conveniences, storage, educational enrichment, reproduction equipment, visual aid equipment, and other teaching aids. Section III-B summarizes the facilities survey in more detail.

## Industrial Survey

A survey of industry was conducted to determine industrial requirements for the training and educational background of industrial drafting personnel. Concerns selected for the survey were stratified according to:

1. Areas of specialization
2. Volume of employment
3. Regional location

It was necessary to explicitly define the geographical regions under study to properly analyze the research data. The selection of regional boundaries was based on natural geographical divisions of the State of Texas as defined by the Texas Highway Department. The defined regions under consideration were:

1. East Texas
2. North Central Texas
3. Central Texas
4. The Panhandle Plains
5. West Texas
6. South Texas -- Gulf Coast
7. Out-of-state

A battery of information forms was designed to explore the occupational requirements of specific areas of specialization. The information requested was categorized by job titles and responsibilities of types of industrial draftsmen. Instructional topics were listed according to specific areas of competence in defined areas of specialization. The yard stick of evaluation was the relative importance of the topic to the occupation responsibility of the job classification.

The topics, or specialties listed, closely paralleled the topics listed under courses of study included in the curriculum survey, and thus gave comparative rating of the various topics as assessed by both industry and educators. Any outstanding differences between ratings are reflected in the drafting course outlines presented in the planning section.

The results of the industrial survey also indicate the distribution of types of drafting job specialties with respect to geographical location, thus providing criteria for selection of program types to be offered by a school in a given location. The industrial survey procedure is summarized in greater detail in Section III-C.

## Combining the Results of Curriculum, Facilities, and Industrial Surveys

This planning guide, particularly Section II, is the result of combining the information obtained from the three surveys.

In keeping with the concept of the "community college," it was felt that the schools could best serve their community by providing courses of study which would train their students in areas where employment opportunities exist. Thus, the needs of local industries as indicated from the industrial survey should play an important role in determining the selection of specialty areas of study which a school should offer. These needs are reflected in Section II where suggestions for selecting specialty courses are made. In addition, the relative importance of topics as assessed by industry, compared to those assessments made by the schools, point out current topics of study which possibly should be emphasized more or less so as to better fit the requirements of a changing technology. (While most educators would agree that industrial involvement in the educational process is desirable, it is interesting to note that relatively few of the industries surveyed indicated that they had ever been approached by a local school to serve as planning consultants, yet their willingness, even eagerness, to do so was indicated.)

Results of the facilities survey enable program planners to estimate their needs in terms of classroom and office equipment which will support their programs.

Program needs in terms of personnel will be established primarily by individual schools, particularly in regard to administrative and clerical personnel. Faculty requirements will be estimated from both enrollment and specialty areas offered, and by the multiplicity of talents possessed by teachers, particularly their ability to teach specialty courses, as well as general courses.

An administrator is naturally concerned with financial outlay. In programs of this type, it is principally the physical requirements which need to be estimated separately; salaries for faculty and staff can usually be estimated from budgets of other departments, since a teacher's subject area does not significantly affect his salary within a given school. On the other hand, a particular technology, such as drafting, requires unique facilities and equipment for which there may be no cost comparison within the school. For this reason, a range of costs of various types of equipment is included in the planning section.

# SECTION II

## PLANNING GUIDE

# SECTION II

# PLANNING GUIDE

## Introduction

This planning guide is intended for use by those assuming the responsibility for planning a two-year associate degree program in Drafting and Design Technology (D & DT). Since the necessary personnel, facilities, equipment and content of such a program are functions of its size, the expected enrollment in the program will be the foundation upon which the planning process is based.

Estimation of program enrollment will be made in terms of percentage of the total enrollment in the entire school for all courses of study. The percentages to be used fall within a 90% confidence interval on the means of such percentages as reported by twenty-one state-supported Texas junior colleges and vocational schools with existing Drafting & Design Technology programs.

The various forms in this planning section have been designed to formalize the process of estimating program requirements in the following areas:

1. Enrollment
2. Curriculum
3. Personnel
4. Facilities and Equipment

To illustrate the use of the various planning forms, a typical example form of each type is shown filled out for a hypothetical case as it is encountered. Blank forms for the reader's use are included in Appendix D.

The planning procedure. As is mentioned above, a prime consideration in the planning of a program of study is that of projected enrollment. The suggested procedures which follow have been designed to consider three possible conditions which might exist prior to establishing a Drafting and Design Technology (D & DT) program:

1. Planning an entirely new school which is to offer a D & DT program within a technical-vocational program.
2. Planning the addition to an existing school of a technical-vocational program which is to include a D & DT program.
3. Planning the addition of a D & DT program to an existing technical-vocational program.

Initial estimates of D & DT enrollment may thus be made from one of the above, depending upon the existing condition.

Once enrollment estimates have been made, the next step is to determine the courses to be offered. A core of basic courses common to all D & DT specialties is suggested which includes both drafting and non-drafting courses. Since non-drafting courses would most probably be administered and taught outside of a drafting department, a brief descriptive title, rather than their detailed content has been included in this guide. Of greater concern is the selection and content of drafting courses, which form the most important part of the D & DT curriculum. Again, a suggested core of required courses is proposed, common to all D & DT specialties, plus a group of specialty drafting courses, from which electives can be selected according to the drafting specialty in which a student wishes to specialize, or which a school elects to offer. A key factor in selecting specialty offerings, in the absence of other criteria (such as student requests,) is the prospect for employment in a particular specialty as evidenced by local industry needs. "Local" as used here is intended to include that geographic region to which graduates of the program might reasonably be expected to migrate, as well as the areas within commuting distance. This guide offers information from which implications for prospective employment may be derived as criteria for selecting specialty course offerings.

Following the estimation of enrollment, and selection of course offerings, an initial estimate of staffing requirements can be made. It is important to note that only an initial estimate can be made at this time because other factors, such as scheduling and classroom availability, must be considered before a final staff complement can be determined. To make the task even more complex, classroom availability cannot be determined until facility requirements have been established; moreover, scheduling, instructor availability and room utilization are inextricably interrelated. The process thus becomes iterative in nature; that is, some assumptions are made concerning the parameters of room utilization desired, number of rooms needed, number of different courses taught per semester, number of students per classroom, number of instructors available, etc. Then the interrelationships are examined and the parameters altered until an optimum arrangement has been approached. This guide provides some formal procedures to assist in reaching an optimum arrangement.

A final step, although not necessarily chronological, as indicated above, is to determine facility and equipment requirements. Major considerations are classroom and office spaces. Within these are furniture such as drawing tables, desks, chairs, etc., plus additional special laboratory and office equipment. Storage and utility areas are also needed. General items may be selected from recommendations given in this guide, and special equipment items are noted along with courses requiring them. Loosely classified under "equipment" are other items such as texts and reference materials. These too are included with each course.

It is hoped that the foregoing has given the reader some concept of the suggested planning procedure which is formalized in the pages which follow. It should be emphasized that these procedures derive from rather broad generalizations based upon consensus of opinion from both schools and industry, and that they are only suggested procedures which may be used in lieu of other equally valid criteria which the user may have at his disposal.

## Enrollment Estimation

To assist in estimating the enrollment in a new Drafting and Design Technology Program, three forms are provided, only one of which should be used, depending upon which of the following conditions exist at the start of the planning procedure:

1. To plan an entirely new school which is to offer a Drafting and Design Technology program within a technical-vocational program: USE FORM II-B-1 ONLY.
2. To plan the addition to an existing school of a technical-vocational program which is to include a Drafting and Design Technology program: USE FORM II-B-2 ONLY.
3. To plan the addition of a Drafting and Design Technology to an existing technical-vocational program: USE FORM II-B-3 ONLY.

SELECT THE FORM WHICH FITS THE APPROPRIATE SITUATION AS DESCRIBED ABOVE.

## FORM II-B-1

## ENROLLMENT ESTIMATION*

EXAMPLE

IF YOU ARE PLANNING A NEW SCHOOL, complete this form to estimate D & DT program enrollment.

Estimated Total School Enrollment . . . . . . . . . . 1500 (1)

Estimated Vocational-Technical Enrollment
(.325 of line (1) ) . . . . (.325 × 1500) . . 488 (2)

Estimated D & DT Program Enrollment
(.139 of line (2) ) . . . . (.139 × 488) . . 68 (3)

---

Summary of Estimated Enrollments:

Estimated D & DT Enrollment from line (3) . . . . . . 68 (A)

Estimated Vocational-Technical Enrollment
from line (2) . . . . . . . . . . . . . . . . . . 488 (B)

Estimated Total Enrollment from line (1) . . . . . . . . 1500 (C)

TURN TO PAGE 18 for a discussion of curriculum development.

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*See Section III-A for source of prediction criteria.

## FORM II-B-2

## ENROLLMENT ESTIMATION*

EXAMPLE

IF YOU ARE ADDING A VOCATIONAL-TECHNICAL PROGRAM TO YOUR SCHOOL, complete this form to estimate D & DT program enrollment.

Present Total School Enrollment . . . . . . . . . . . 1000 (1)

Estimated Vocational-Technical Enrollment (.481 of line (1) ) . . . . (.481× 1000) . . . . 481 (2)

Estimated D & DT Enrollment (.139 of line (2) ) . . . . (.139×481) . . . . . . 66 (3)

Estimated Total Enrollment After Adding Vocational-Technical Program (sum of lines (1) and (2) ) . . . 1481 (4)

---

Summary of Estimated Enrollments:

Estimated D & DT Enrollment from line (3) . . . . . . . 66 (A)

Estimated Vocational-Technical Enrollment from line (2) . . . . . . . . . . . . . . . . . . . 481 (B)

Estimated Total Enrollment from line (4) . . . . . . . . 1481 (C)

TURN TO PAGE 18 for a discussion of curriculum development.

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* See Section III-A for source of prediction criteria.

FORM II-B-3

ENROLLMENT ESTIMATION* EXAMPLE

IF YOU ARE ADDING A D & DT PROGRAM TO YOUR EXISTING VOCATIONAL-TECHNICAL PROGRAM, complete this form to estimate D & DT enrollment.

Present Total School Enrollment . . . . . . . . . . . 1400 (1)

Present Vocational-Technical Enrollment . . . . . . 400 (2)

Estimated D & DT Enrollment (.161 of line (2) ) . . . 64 (3)

Estimated Vocational-Technical Enrollment After Adding D & DT Program (sum of lines (2) and (3) ) 464 (4)

Estimated Total Enrollment After Adding D & DT Program (sum of lines (1) and (3) ) . . . . . . . . . 1464 (5)

---

Summary of Estimated Enrollments:

Estimated D & DT Enrollment from line (3) . . . . . . 64 (A)

Estimated Vocational-Technical Enrollment from line (4) . . . . . . . . . . . . . . . . . 464 (B)

Estimated Total Enrollment from line (5) . . . . . . . . 1464 (C)

TURN TO PAGE 18 for a discussion of curriculum development.

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*See Section III-A for source of prediction criteria.

## Determination of Curriculum

The selection of what is to be taught is perhaps the most important consideration in the planning of any educational endeavor, for it is the program content around which the selection of facilities and faculty and the implementation of educational experiences revolves. The steps which follow represent a suggested procedure which might be used in formulating course offerings in a Drafting and Design Technology program. As in all the suggestions offered in this guide, they serve as planning criteria only in the absence of other criteria which the user may have at his disposal, and which have proven to be equally as valid.

It is assumed that at this point the user has already made an initial estimate of expected enrollment in the new program, and is now ready to consider its content. The approach to be taken follows these steps:

1. Acceptance of the suggested basic core offerings, or a modification thereof.

2. Selection of specialty areas of Drafting and Design Technology for which courses must be provided. This selection to be based upon an examination of local industry needs, as indicated by the industrial survey portion of this study, also from expressed student desires, and any other pertinent sources.

3. Construction of balanced courses of study comprising basic core courses and specialty courses selected from steps 1 and 2. Balance may be accomplished by including student-selected elective enrichment courses.

The general scheme of courses suggested for a typical Drafting and Design Technology program is shown on page 20, which lists the types of courses classified according to whether they are basic core or elective courses. A more detailed listing including specific courses and credit hours is found on pages 21 and 22. A complete course of study is assumed to be approximately 66 to 68 credit hours, based upon a four-semester program. It will be noted that completion of only the required courses listed will not satisfy this credit hour requirement (they total only 49 credit hours), thus the student must elect approximately 17 to 19 additional hours, or six extra three-hour courses. As will be seen, at least two of these will be from the drafting electives, representing the chosen specialty area. It is recommended that the remaining electives be chosen so as to support the specialty area.

Following the curriculum listing, and beginning on page 23, are brief descriptions of each drafting course. These are given for rapid reference, and are repeated as needed later as the user proceeds through the planning process.

Assuming that the content of the basic core has been accepted, the next step is to select appropriate specialty and elective courses to fill out the program. The map on page 28 and Form II-C-1 on page 30 have been provided to assist in making this selection.

## SUGGESTED COURSE AREAS FOR DRAFTING AND DESIGN TECHNOLOGY

### Basic Core--Non-Drafting Courses:

- Communicative Arts
- Basic Sciences
- Mathematics
- Engineering Technology
- Humanities, Business, Social Science
- Health and Physical Education

### Basic Core--Drafting Courses:

- Basic Drafting
- Descriptive Geometry
- Architectural
- Electrical and Electronic
- Structural

### Elective Specialties--Drafting Courses

### Other Electives--Non-Drafting Courses

## SUGGESTED CURRICULUM

### 32-45 Hours Non-Drafting Courses

Communicative Arts: 6-9 hours

| | | Credit Hours | |
|---|---|---|---|
| Required: | Composition and Rhetoric | 3 | |
| | Technical Writing | 3 | |
| Elective: | Public Speaking | | 3 |

Basic Science: 8-12 hours

| | | | |
|---|---|---|---|
| Required: | Physics I--Statics and Mechanics | 4 | |
| | Physics II--Heat, Light, Electricity | 4 | |
| Elective: | Chemistry | | 4 |
| | Biology | | 3 |

Mathematics: 6-12 hours

| | | | |
|---|---|---|---|
| Required: | Algebra | 3 | |
| | Trigonometry | 3 | |
| Elective: | Analytic Geometry | | 3 |
| | Calculus | | 3 |
| | Numerical Analysis | | 3 |

Engineering Technology: 6-12 hours

| | | | |
|---|---|---|---|
| Required: | Manufacturing Materials & Processes | 3 | |
| | Shop Practice | 3 | |
| Elective: | Electronic Technology | | 3 |
| | Surveying | | 3 |
| | Aeronautical Technology | | 3 |
| | Computer Programming | | 3 |
| | Numerical Control | | 3 |

SUGGESTED CURRICULUM--Continued

| Humanities, Business, Social Studies: 5-8 hours | | Credit Hours | |
|---|---|---|---|
| Required: | Orientation--College and Vocational | 2 | |
| Elective: | History | | 3 |
| | Government | | 3 |
| | Business Administration | | 3 |

| Health & Physical Education: 0-2 hours | | | |
|---|---|---|---|
| Required: | Physical Education I | 0 | |
| | Physical Education II | 0 | |
| Elective: | Physical Education III | | 1 |
| | Physical Education IV | | 1 |

24-36 Hours Drafting Courses

| | | | |
|---|---|---|---|
| Required: | Basic Drafting | 3 | |
| | Machine Drafting | 3 | |
| | Descriptive Geometry | 3 | |
| | Building Construction I | 3 | |
| | Electrical & Electronic | 3 | |
| | Structural I | 3 | |
| Elective:* | Aeronautical | | 3 |
| | Building Construction II | | 3 |
| | Structural II | | 3 |
| | Technical Illustration I | | 3 |
| | Technical Illustration II | | 3 |
| | Numerical Control Graphics | | 3 |
| | Machine & Tool Design | | 3 |
| | Map & Topographic Drafting | | 3 |
| | Sheet Metal Drafting | | 3 |
| | Piping Drafting | | 3 |
| | Pattern, Foundry and Forging Drawings | | 3 |
| | Graphical Analysis | | 3 |

*At least two of these must be selected to satisfy minimum drafting credit requirements.

## DRAFTING COURSE DESCRIPTIONS

Aeronautical Drafting (Elective). Prerequisites--All Basic Core drafting courses

A course designed for drafting students who will enter the aircraft/aerospace industry. Particular emphasis on drafting practices concerned with airframe structures and materials, and the requirements of the aerodynamic-structural-mechanical system. Modern techniques and materials peculiar to craft operating outside the earth's atmosphere and gravitational field.

Basic Drafting (Required). Prerequisites--none

An introductory course in drafting emphasizing fundamental knowledge and skills required for fluency in graphical communication. Considerable time spent on developing proper techniques and habits in drafting ability through practice. Skills obtained in this course are prerequisite for and common to all drafting areas.

Building Construction Drafting I (Required). Prerequisites--none

A first course in architectural drafting, introducing conventional techniques and methods used to represent building structures and their specifications. Intended to enable the draftsman to recognize building structure as a part of an overall engineering system.

Building Construction II (Elective). Prerequisites--All Basic Core drafting courses

A continuation of Architectural Drafting I, designed for students who wish to specialize in architectural drafting. Additional emphasis placed on building codes and specifications, modern construction methods, and commercial building requirements. Preparation of building site plans and details within buildings.

Descriptive Geometry (Required). Prerequisites--Basic Drafting

Theory and applications of spatial geometry to graphical representation and analysis of technological problems. Development of relations between fundamental geometric elements of points, lines, and surfaces, and the use of these elements in analyzing and solving problems in selected representative areas of technology.

Electrical and Electronic Drafting (Required). Prerequisites--Basic Drafting, Machine Drafting

A course emphasizing conventional techniques and methods of representing electrical and electronic systems, with particular attention to modern electro-physical advancements and precision layout of miniature and microminiature circuitry.

Foundry Drafting (Elective). Prerequisites--All Basic Core drafting courses

Drafting practices applied to foundry production methods. Basics of pattern making, casting and related shop processes. Preparation of detail drawings for specifications required by those processes, with emphasis on dimensional requirements. Designed for students to enter industries relying heavily on foundry production.

Graphical Analysis (Elective). Prerequisites--All Basic Core courses.

A course emphasizing graphical methods for data analysis and reduction, including nomography and empirical formula derivation. Graphical methods to simplify the solution of equations. Of value to students likely to be involved in laboratory work and technical report preparation.

Machine Drafting (Required). Prerequisities--Basic Drafting

A continuation of Basic Drafting with additional emphasis on industrial applications of drafting. Methods of representing more complex and specialized areas of application, with consideration given to specifications for controlled precision production of mechanical systems.

Machine and Tool Drafting (Elective). Prerequisites--All Basic Core drafting courses

Intended for students who wish to specialize in mechanical design drafting. Emphasis on design and analysis of basic drive mechanisms, including gears, cams and linkages. Jig and fixture design for quantity production. Production quality control and numerically-controlled tools. Individual and group projects.

Map & Topographic Drafting (Elective).

Designed to prepare the draftsman to specialize in map construction. Use of survey field data. Topographic drafting. Types of global projections; conformal, equal area and others. Use of special mapping instruments. Non-geographical mapping. Introduction to photogrammetry and stereo mapping.

Numerical Control Graphics (Elective). Prerequisites--Computer Programming and all Basic Core drafting courses

An introductory course intended to demonstrate existing and potential uses of graphical input/output with high-speed digital computers. Applications to automatic control of production tools. Capabilities of both on-line and off-line printers, plotters and cathode-ray tube display devices. Use of standard coding languages, such as FØRTRAN and APT. Graphical modes of man-machine communication.

Pipe & Vessel Detailing (Elective). Prerequisites--All Basic Core drafting courses

Design, layout and graphical treatment of piping systems. Emphasis on standard symbols and nomenclature, and schematic, pictorial and multiview representation. Vessels, control and metering devices, and piping materials. Strongly recommended for students planning to enter industries using hydraulic or chemical processes.

Sheet Metal Drafting (Elective). Prerequisites--All Basic Core drafting courses

Design and layout of patterns for fabrication from sheet materials. Emphasis on theory of developments, sheet materials, forming processes, and use of standard forming tables. Recommended for students planning to enter industries in which sheet construction is used, such as aircraft skin structures, pressure vessels, or metal cabinetry.

Structural Drafting I (Required). Prerequisites--Basic Drafting, Machine Drafting, Descriptive Geometry

A first course in methods and techniques of representation and elementary design of conventional steel and concrete structural components. Extensive use of standard tables and specifications for selection and representation of components for typical structures. Methods of scheduling and estimating materials. Introduction to detailing reinforced concrete components.

Structural Drafting II (Elective). Prerequisites--Structural Drafting I and all Basic Core drafting courses

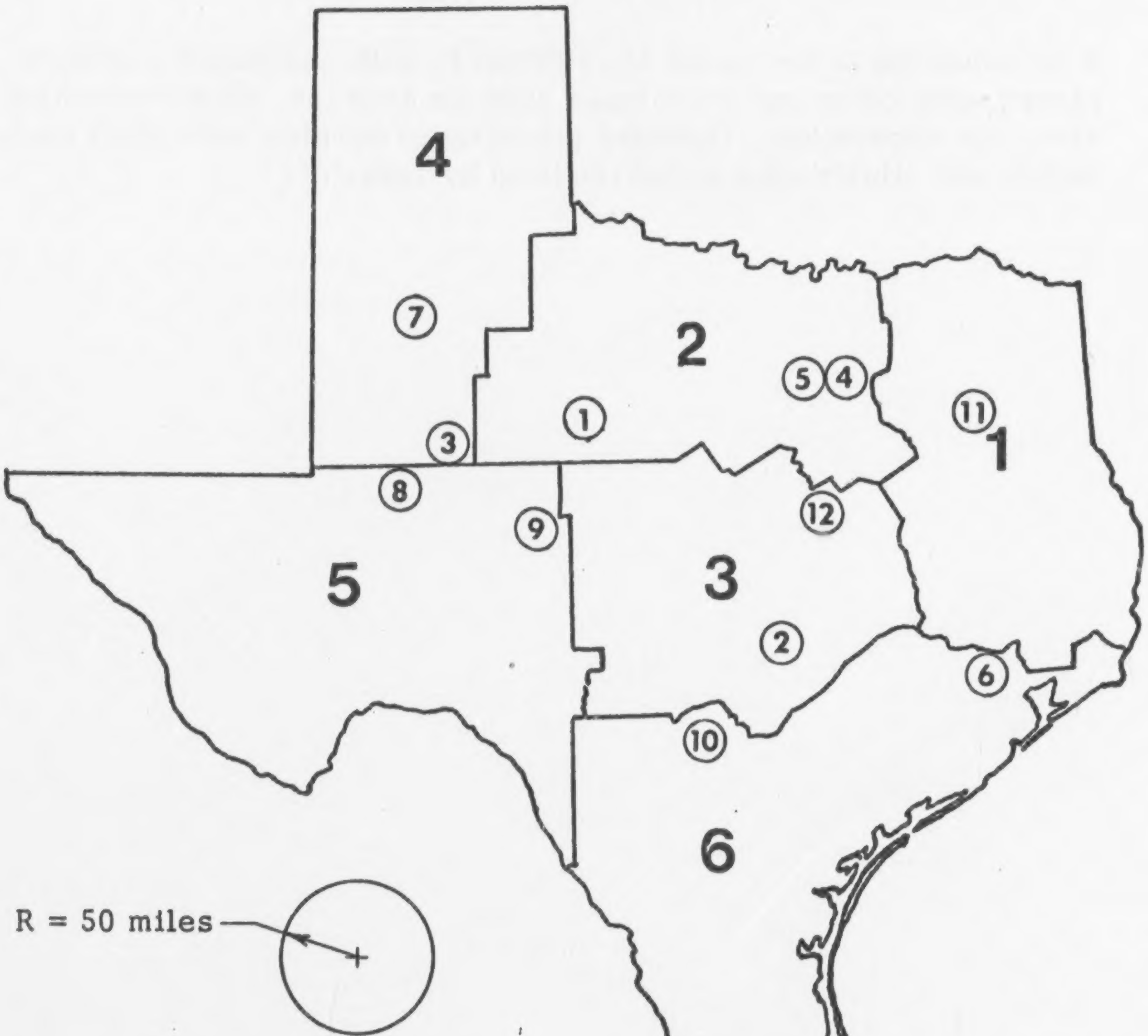
A continuation of Structural Drafting I, placing additional emphasis on advanced detailing and design of steel and concrete structures and their components. Discussion of modern structural trends utilizing cable-supported and shell structures.

Technical Illustration I (Elective) Prerequisites--All Basic Core drafting courses

A first course for students intending to work as technical illustrators. Emphasis on pictorial representation, with introduction to rendering techniques and media used to enhance illustration realism. Use of materials such as prepared lettering and shading films. Preparation for publication illustration and technical manuals.

Technical Illustration II (Elective). Prerequisites-- Technical Illustration I and all Basic Core drafting courses

A continuation of Technical Illustration I, with additional emphasis placed upon advanced techniques such as airbrush, photoretouching and color separation. Intended primarily to develop individual student ability and illustrating skills required by industry.


4
⑦
2
⑤④
①
③
⑪
1
⑧
⑨
⑫
5
3
②
⑥
⑩
6
R = 50 miles

Key Cities:

① Abiliene
② Austin
③ Big Spring
④ Dallas
⑤ Fort Worth
⑥ Houston
⑦ Lubbock
⑧ Midland
⑨ San Angelo
⑩ San Antonio
⑪ Tyler
⑫ Waco

Fig. 1--Distribution of industrial regions in Texas

The map is shown divided into sections from which information from the industrial survey was obtained. The user should locate his school on this map, then proceed as follows:

1. Determine which region or regions on the map are most likely to have some influence on course offerings. Although some subjective judgment may be required here, it is not unreasonable to consider a region of influence within a certain radius of the school, such as might represent a commuting distance for local students, or a distance to which students would be likely to migrate upon graduation. It is suggested that a 50-mile radius would represent a maximum area of influence.

2. Having ascertained which regions would have influence upon course offerings, proceed to Form II-C-1 (page 30), which indicates the distribution of specialty draftsmen employed in those regions. Mark the geographical regions to be served by your graduates by circling the appropriate section numbers at the top of the columns. Considering only the figures in these columns, place the totals for each horizontal row in the right hand column. This column will represent the approximate distribution of specialty draftsmen in the regions selected. The figures in this column may be used as an approximate indication of what specialty areas should be considered in the total curriculum, assuming that the employment distribution represented thereby will remain relatively constant constant in the future.

Obviously, no predictions can be made concerning the possibility of new industries locating in or leaving the influence sections which could alter the distribution, and this possibility is recognized by planners. Curriculum planning must be considered as a relatively short-term venture, or more correctly, as a continuing process.

## FORM II-C-1

## SPECIALTY TYPE SELECTION

EXAMPLE

(Number of specialty draftsmen employed
in Texas industrial regions*)

| TYPES OF DRAFTSMEN (Check those which apply) | REGION (See map, page 28) (Circle those which apply) | | | | | | Total of Applicable Sections |
|---|---|---|---|---|---|---|---|
| | 1 | [✓ 2] | [✓ 3] | 4 | 5 | 6 | |
| ☐ Aeronautical | 0 | 7 | 0 | 0 | 4 | 68 | 7 |
| ☑ Architectural | 20 | 100 | 32 | 5 | 24 | 113 | 132 (5) |
| ☑ Civil | 48 | 154 | 3 | 25 | 19 | 273 | 157 (4) |
| ☐ Electrical | 36 | 50 | 4 | 6 | 12 | 130 | 54 |
| ☑ Electro-Mechanical | 40 | 349 | 38 | 0 | 12 | 149 | 387 (2) |
| ☐ Electronic | 0 | 109 | 10 | 0 | 4 | 25 | 119 |
| ☐ Mapping | 15 | 18 | 54 | 21 | 72 | 181 | 72 |
| ☑ Mechanical | 57 | 643 | 18 | 20 | 11 | 286 | 661 (1) |
| ☐ Oil & Gas (Piping) | 27 | 20 | 0 | 12 | 16 | 380 | 20 |
| ☑ Structural | 30 | 134 | 77 | 11 | 23 | 352 | 211 (3) |
| ☐ Technical Illustration | 1 | 118 | 8 | 0 | 8 | 72 | 126 |
| ☐ Tool Design | 1 | 96 | 5 | 5 | 10 | 27 | 101 |

*Based upon a survey of 329 industrial firms.

The selection of specialty courses to be included in the curriculum will depend to some extent upon enrollment estimates. It would be uneconomical to provide for courses in so many specialties that class size would be below a feasible minimum. Thus, it is suggested that no more specialties be selected than would be represented by the number of minimum-size classes that could be held. Many schools have erred in this respect; in attempting to accommodate all students, they have "spread themselves too thinly" by carrying many courses in their curricula which are seldom taught because not enough students are enrolled in them. This often leads to disappointment and frustration on the student's part, with resulting disenchantment with the school, and subsequent damage to the school's reputation. On the other hand, if the courses are not offered to start with, there is no student expectation to be damaged, and courses can usually be added if there is sufficient demand.

An initial selection of specialty areas to consider can be made as follows, using the figures on FORM II-C-1:

1. Divide total estimated D & DT enrollment by the smallest feasible (advanced) class size. The result is the maximum number of different specialty areas for which classes could be provided.

2. In FORM II-C-1, beginning with the largest figure in the right-hand column, indicate the corresponding specialty area by placing a check next to it in the left-hand column.

3. Continue this process for the next largest figure, etc., until the maximum number (from step 1.) of specialty areas has been checked. These will represent a selection of specialty areas around which the curriculum is to be constructed.

Once the selection of specialty areas to be offered has been made, a listing of appropriate course offerings can be compiled, using FORMS II-C-2A and II-C-2B, pages 33 and 34. Solid circles in the chart represent courses which are strongly recommended for each specialty, while open circles represent suggested supporting electives.

The selected specialty areas should be indicated by checking the box in front of each. The last line in the form may be completed by considering the symbols found under each course for the specialty areas checked. If a black symbol is found, enter a black symbol in the last box under that course. If only white symbols are found, enter a white symbol. If no symbols are encountered, leave the box blank. Thus the last row will represent a summary of required and elective courses to be added to the basic core to support the selected specialty areas.

## FORM II-C-2A

## NON-DRAFTING COURSES RECOMMENDED IN ADDITION TO BASIC CORE COURSES

EXAMPLE

Symbols in this form indicate the following:

**O** Required Courses
O Recommended Electives

(Check those selected)

| | Drafting Specialty | Courses | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Public Speaking | Chemistry | Biology | Analytic Geometry | Calculus | Numerical Analysis | Electronic Technology | Surveying | Aeronautical Technology | Computer Programming | Numerical Control | History | Government | Business Administration |
| ☐ | Aeronautical | | | | O | | | | | O | O | O | | | |
| ☑ | Architectural | O | | | O | | | | **O** | | | | | | O |
| ☑ | Civil | | | | O | | | | **O** | | O | O | | | O |
| ☐ | Electrical | | | | O | | | **O** | | | | | | | |
| ☑ | Electro-Mechanical | | O | | O | O | O | **O** | | O | O | O | | | |
| ☐ | Electronic | | O | | O | | | **O** | | | | | | | |
| ☐ | Mapping | | | | O | O | | | **O** | | O | O | | | O |
| ☑ | Mechanical | | | | **O** | O | O | | | | **O** | O | | | |
| ☐ | Oil & Gas (Piping) | | **O** | | O | | | | **O** | | | | | | O |
| ☑ | Structural | | | | **O** | | | | O | O | O | O | | | |
| ☐ | Technical Illustration | O | | O | **O** | | | | O | | | | | | O |
| ☐ | Tool Design | | | | O | O | O | | | | **O** | O | | | |
| | Summary | O | O | | **O** | O | O | **O** | **O** | O | **O** | O | | | O |

FORM II-C-2B

## DRAFTING COURSES RECOMMENDED IN ADDITION TO BASIC CORE COURSES

EXAMPLE

Symbols in this form indicate the following:

**○** Required Courses
○ Recommended Electives

(Check those selected)

| | Drafting Specialty | Aeronautical | Architectural II | Structural II | Technical Illustration I | Technical Illustration II | Computer Graphics | Machine & Tool Design | Cartography | Sheet Metal Drafting | Piping Drafting | Pattern, Foundry & Forging Drawing | Graphical Analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ☐ | Aeronautical | **○** | | | **○** | | ○ | | | ○ | ○ | | ○ |
| ☑ | Architectural | | **○** | ○ | ○ | ○ | | | ○ | | ○ | | |
| ☑ | Civil | | | **○** | ○ | | ○ | | **○** | | ○ | | ○ |
| ☐ | Electrical | ○ | | | ○ | | | **○** | | ○ | **○** | | ○ |
| ☑ | Electro-Mechanical | | | | **○** | | ○ | **○** | | ○ | ○ | ○ | |
| ☐ | Electronic | ○ | | | **○** | | ○ | ○ | | **○** | | | ○ |
| ☐ | Mapping | | | | **○** | | ○ | | **○** | | ○ | | ○ |
| ☑ | Mechanical | | | | **○** | | ○ | **○** | | ○ | ○ | ○ | |
| ☐ | Oil & Gas (Piping) | | | | ○ | | | ○ | **○** | | **○** | | ○ |
| ☑ | Structural | | | **○** | ○ | | ○ | | | ○ | | ○ | ○ |
| ☐ | Technical Illustration | ○ | ○ | | **○** | **○** | | ○ | | | | | ○ |
| ☐ | Tool Design | | | | **○** | | ○ | **○** | | | | ○ | ○ |
| | Summary | | **○** | **○** | ○ | ○ | ○ | **○** | **○** | ○ | ○ | ○ | ○ |

A partially complete curriculum listing, FORM II-C-3, is found on pages 36 through 38 , with only the basic core courses listed. The specialty courses selected from FORMS II-C-2A and II-C-2B may be entered under their appropriate categories, thereby obtaining a tentative list of courses to be offered in a Drafting & Design Technology program.

FORM II-C-3

Summary of Course Offerings EXAMPLE

(Supply the appropriate courses from FORMS II-C-2A and II-C-2B in the blank spaces.)

Communicative Arts:

Required: Composition & Rhetoric
Technical Writing

Electives: Public Speaking
____________________
____________________

Basic Science:

Required: Physics I--Statics & Mechanics
Physics II--Heat, Light & Electricity

Electives: Chemistry
____________________
____________________

Mathematics:

Required: College Algebra
Trigonometry

Electives: Analytic Geometry
Calculus
Numerical Analysis

FORM II-C-3--Continued

Engineering Technology:

Required: Manufacturing Materials & Processes
Shop Practice

Electives: Electronic Technology
Surveying
Aeronautical Technology
Computer Programming
Numerical Control

Humanities, Business, Social Studies:

Required: Orientation

Electives: Business Administration

Health & Physical Education:

Required: Health & Physical Education I
Health & Physical Education II

Electives:

FORM II-C-3--Continued

Drafting:

Required:
- Basic Drafting
- Machine Drafting
- Building Construction Drafting I
- Descriptive Geometry
- Electrical & Electronic Drafting
- Structural Drafting I

Electives:
- Building Construction Drafting II
- Structural Drafting II
- Tech. Illustration I
- Tech. Illustration II
- Computer Graphics
- Machine & Tool Design
- Cartography
- Sheet Metal Drafting
- Piping Drafting
- Foundry Drafting
- Graphical Analysis

A suggested minimum curriculum outline, by semester, is given on pages 40 and 41. The outline is designed to accomodate all specialties by providing for appropriate elective courses (beyond the first semester, which is common to all areas). FORMS II-C-4A through II-C-4L, pages 44 through 67, are provided to assist in designing complete courses of study for each specialty. Each of these forms includes a job title, job description, and proportion of drafting personnel represented by that job title in Texas based upon a survey of 329 Texas industries (Walston, 1969). The suggested courses of study by semester include the courses recommended to support each specialty, with additional space provided for adding enrichment electives. These forms may prove to be helpful in counseling, and may be reproduced in quantity if needed.

The last part of this curriculum planning section consists of detailed content analysis of each drafting course, with major topics listed first, then subtopical breakdown under each of these. Some suggested texts and other reference materials, as well as any special equipment or facilities needed, are also included.

## SUGGESTED MINIMUM CURRICULUM
## OUTLINE BY SEMESTER--ALL SPECIALTIES

### First Semester

| Course | Credit Hours |
|---|---|
| Composition and Rhetoric | 3 |
| College Algebra | 3 |
| Orientation | 2 |
| Manufacturing Materials and Processes | 3 |
| Basic Drafting I | 3 |
| Building Construction Drafting I | 3 |
| Physical Education I | R |
| TOTAL | 17 |

### Second Semester

| Course | Credit Hours |
|---|---|
| Technical Writing | 3 |
| Trigonometry | 3 |
| Shop Practice | 3 |
| Machine Drafting | 3 |
| Descriptive Geometry | 3 |
| *Elective--Engineering Technology | 3 |
| Physical Education II | R |
| TOTAL | 18 |

### Third Semester

| Course | Credit Hours |
|---|---|
| Physics I | 4 |
| Electrical and Electronic Drafting | 3 |
| Structural Drafting I | 3 |
| *Elective--Drafting | 3 |
| *Elective--Basic Science or Mathematics | 3 |
| TOTAL | 16 |

## Fourth Semester

| Course | | Credit Hours |
|---|---|---|
| Physics II | | 4 |
| *Elective--Social Studies | | 3 |
| *Elective--Drafting | | 3 |
| *Elective--Drafting or Non-Drafting | | 3 |
| *Elective--Drafting or Non-Drafting | | 3 |
| | TOTAL | 16 |

## FORMS II-C-4A TO II-C-4L:

## SUGGESTED COURSES OF STUDY

# General Draftsman

The following job description is given for reference as needed when examining job descriptions of types of draftsmen on the following pages, some of which refer to the duties of Draftsman I:

Draftsman I.

Prepares clear, complete, and accurate working plans and detail drawings from rough or detailed sketches or notes for engineering or manufacturing purposes, according to specified dimensions: Makes final sketch of proposed drawing, checking dimension of parts, materials to be used, relation of one part to another, and relation of various parts to the whole structure. Makes any adjustments or changes necessary or desired. Inks in all lines and letters on pencil drawings as required. Exercises manual skill in manipulation of triangle, T-square, and other drafting tools. Lays tracing paper on drawing and traces drawing in ink. Draws finished designs from sketches. Utilizes knowledge of various machines, engineering practices, mathematics, building materials, and other physical sciences to complete drawings. Classifications are made according to type of drafting as Draftsman, Architectural; Draftsman, Electrical.

Note: All job descriptions given here are taken from the Dictionary of Occupational Titles.

FORM II-C-4A

(NOT OFFERED) EXAMPLE

Job Title: Aeronautical Draftsman

Job Description: Performs duties of Draftsman I, specializing in drafting engineering drawings of developmental or production airplanes and missiles and ancillary equipment, including launch mechanisms and scale models of prototype aircraft, as planned by Aeronautical Engineer.

Percent of total drafting personnel surveyed in Texas who are employed in the above capacity (1969): 1.7%

Suggested Course of Study:

First Semester

| | |
|---|---|
| Composition and Rhetoric | (3-0) 3* |
| College Algebra | (3-0) 3 |
| Orientation | (2-0) 2 |
| Manufacturing Materials and Processes | (3-0) 3 |
| Basic Drafting | (2-4) 3 |
| Building Construction Drafting I | (2-4) 3 |
| Physical Education I | R |
| TOTAL | (15-8) 17 |

Second Semester

| | |
|---|---|
| Technical Writing | (3-0) 3 |
| Trigonometry | (3-0) 3 |
| Shop Practice | (2-4) 3 |
| Machine Drafting | (2-4) 3 |
| Descriptive Geometry | (2-4) 3 |
| Aeronautical Technology | (3-0) 3 |
| Physical Education II | R |
| | (15-12) 18 |

---

*These figures are interpreted as 3 clock hours lecture and zero clock hours laboratory per week; 3 credit hours.

## FORM II-C-4A--Continued

### Third Semester

| | | |
|---|---|---|
| Physics I | | (3-4) 4 |
| Electrical and Electronic Drafting | | (2-4) 3 |
| Structural Drafting I | | (2-4) 3 |
| Technical Illustration I | | (2-4) 3 |
| Science or Math Elective: | | |
| ______________________________ | | (3-0) 3 |
| | TOTAL | (12-16) 16 |

### Fourth Semester

| | | |
|---|---|---|
| Physics II | | (3-4) 4 |
| Aeronautical Drafting | | (2-4) 3 |
| Social Studies Elective: | | |
| ______________________________ | | (3-0) 3 |
| General Elective: | | |
| ______________________________ | | (    ) 3 |
| General Elective: | | |
| ______________________________ | | (    ) 3 |
| | TOTAL | (    ) 16 |

FORM II-C-4B

EXAMPLE

Job Title: Architectural Draftsman

Job Description: Performs duties of Draftsman I by planning artistic architectural and structural features of any class of buildings and like structures: Sketches designs and details, using drawing instruments. Makes engineering computations involved in the strength of material, beams, and trusses. Estimates quantities needed for project and computes cost. Makes freehand drawings of proposed structure when necessary to clarify plans. May specialize in planning architectural details according to structural materials used as Tile and Marble Draftsman.

Percent of total drafting personnel surveyed in Texas who are employed in the above capacity (1969): 6.3%

Suggested Course of Study:

First Semester

(Common to all areas; see FORM II-C-4A, Aeronautical Draftsman, page 44 .)

Second Semester

| | | |
|---|---|---|
| Technical Writing | | (3-0) 3 |
| Trigonometry | | (3-0) 3 |
| Shop Practice | | (2-4) 3 |
| Machine Drafting | | (2-4) 3 |
| Descriptive Geometry | | (2-4) 3 |
| Surveying | | (3-0) 3 |
| Physical Education II | | R |
| | TOTAL | (15-12) 18 |

FORM II-C-4B--Continued

### Third Semester

| | | |
|---|---|---|
| Physics I | | (3-4) 4 |
| Electrical & Electronic Drafting | | (2-4) 3 |
| Structural Drafting I | | (2-4) 3 |
| Technical Illustration I | | (2-4) 3 |
| Science or Math Elective: | | |
| Analytic Geometry | | (3-0) 3 |
| | TOTAL | (12-16) 16 |

### Fourth Semester

| | | |
|---|---|---|
| Physics II | | (3-4) 4 |
| Technical Illustration II | | (2-4) 3 |
| Building Construction Drafting II | | (2-4) 3 |
| Social Studies Elective: | | |
| History or Gov't. | | (3-0) 3 |
| General Elective: | | |
| (Student Selected) | | ( ) 3 |
| | TOTAL | ( ) 16 |

FORM II-C-4C

EXAMPLE

Job Title: Civil Draftsman

Job Description: Drafts detailed construction drawings, topographical profiles, and related maps and specification sheets used in planning and construction of highways, river and harbor improvements, flood control, drainage, and other civil engineering projects, performing duties as described under Draftsman I: Plots maps and charts showing profiles and cross sections, indicating relation of topographical contours and elevations to buildings, retaining walls, tunnels, overhead powerlines, and other structures. Drafts detailed drawings of structures and installations, such as roads, culverts, fresh water supply and sewage disposal systems, dikes, wharfs, and breakwaters. Computes volume of tonnage of excavations and fills, and prepares graphs and hauling diagrams used in earthmoving operations. May accompany survey crew in field to locate grading markers or to collect data required for revision of construction drawings. May be designated according to type of construction as Reinforced Concrete Draftsman or Water and Sewage Draftsman.

The above description also fits the following titles: Civil Engineering Draftsman, Engineering Draftsman, Construction Draftsman.

Percent of total drafting personnel surveyed in Texas who are employed in the above capacity (1969): 11.1%

Suggested Course of Study:

First Semester

(Common to all areas; see FORM II-C-4A Aeronautical Draftsman, page 44.)

FORM II-C-4C--Continued

### Second Semester

| | | |
|---|---|---|
| Technical Writing | | (3-0) 3 |
| Trigonometry | | (3-0) 3 |
| Shop Practice | | (2-4) 3 |
| Machine Drafting | | (2-4) 3 |
| Descriptive Geometry | | (2-4) 3 |
| Surveying | | (3-0) 3 |
| Physical Education II | | R |
| | TOTAL | (15-12) 18 |

### Third Semester

| | | |
|---|---|---|
| Physics I | | (3-4) 4 |
| Electrical & Electronic Drafting | | (2-4) 3 |
| Structural Drafting I | | (2-4) 3 |
| Map & Topographic Drafting | | (2-4) 3 |
| Science or Math Elective: | | |
| Analytic Geometry | | (3-0) 3 |
| | TOTAL | (12-16) 16 |

### Fourth Semester

| | | |
|---|---|---|
| Physics II | | (3-4) 4 |
| Structural II | | (2-4) 3 |
| Social Studies Elective: | | |
| History or Gov't. | | (3-0) 3 |
| General Elective: | | |
| (Student Selected) | | ( ) 3 |
| General Elective: | | |
| (Student Selected) | | ( ) 3 |
| | TOTAL | ( ) 16 |

FORM II-C-4D

EXAMPLE
(NOT OFFERED)

Job Title: Electrical Draftsman

Job Description: Performs duties of Draftsman I in preparing electrical equipment working drawings and wiring diagrams used by construction crews and repairman who erect, install, and repair electrical equipment and wiring in powerplants, industrial establishments, commercial or domestic buildings, or electrical distribution systems.

Percent of total drafting personnel surveyed in Texas who are employed in the above capacity (1969): 5.1%

Suggested Course of Study:

First Semester

(Common to all areas; see FORM II-C-4A, Aeronautical Draftsman, page 44.)

Second Semester

| | | |
|---|---|---|
| Technical Writing | | (3-0) 3 |
| Trigonometry | | (3-0) 3 |
| Shop Practice | | (2-4) 3 |
| Machine Drafting | | (2-4) 3 |
| Descriptive Geometry | | (2-4) 3 |
| Electronic Technology | | (3-0) 3 |
| Physical Education II | | R |
| | TOTAL | (15-12) 18 |

FORM II-C-4D--Continued

### Third Semester

| | | |
|---|---|---|
| Physics I | | (3-4) 4 |
| Electrical & Electronic Drafting | | (2-4) 3 |
| Structural Drafting I | | (2-4) 3 |
| Machine & Tool Drafting | | (2-4) 3 |
| Science or Math Elective: | | |
| ________________________________ | | (3-0) 3 |
| | TOTAL | (12-16) 16 |

### Fourth Semester

| | | |
|---|---|---|
| Physics II | | (3-4) 4 |
| Piping Drafting | | (2-4) 3 |
| Social Studies Elective: | | |
| ________________________________ | | (3-0) 3 |
| General Elective: | | |
| ________________________________ | | (    ) 3 |
| General Elective: | | |
| ________________________________ | | (    ) 3 |
| | TOTAL | (    ) 16 |

FORM II-C-4E

EXAMPLE

Job Title: Electro-Mechanical Draftsman

Job Description: (No formal job description is given in the Dictionary of Occupational Titles; however, many industrial respondents classified their drafting personnel in this category. It is suggested that the job descriptions for the Electrical Draftsman, FORM II-C-4D Electronic Draftsman, FORM II-C-4F, and Mechanical Draftsman, FORM II-C-4H, be used as a guide.)

Percent of total drafting personnel surveyed in Texas who are employed in the above capacity (1969): 12.5%

Suggested Course of Study:

First Semester

(Common to all areas; see FORM II-C-4A, Aeronautical Draftsman, page 44 .)

Second Semester

| | | |
|---|---|---|
| Technical Writing | | (3-0) 3 |
| Trigonometry | | (3-0) 3 |
| Shop Practice | | (2-4) 3 |
| Machine Drafting | | (2-4) 3 |
| Descriptive Geometry | | (2-4) 3 |
| Electronic Technology | | (3-0) 3 |
| Physical Education II | | R |
| | TOTAL | (15-12) 18 |

## FORM II-C-4E--Continued

### Third Semester

| | | |
|---|---|---|
| Physics I | | (3-4) 4 |
| Electrical & Electronic Drafting | | (2-4) 3 |
| Structural Drafting I | | (2-4) 3 |
| Technical Illustration I | | (2-4) 3 |
| Analytic Geometry | | (3-0) 3 |
| | TOTAL | (12-16) 16 |

### Fourth Semester

| | | |
|---|---|---|
| Physics II | | (3-4) 4 |
| Machine & Tool Drafting | | (2-4) 3 |
| Social Studies Elective: | | |
| HISTORY OR GOV'T. | | (3-0) 3 |
| General Elective: | | |
| (STUDENT SELECTED) | | ( ) 3 |
| General Elective: | | |
| (STUDENT SELECTED) | | ( ) 3 |
| | TOTAL | ( ) 16 |

FORM II-C-4F EXAMPLE
(NOT OFFERED)

Job Title: Electronic Draftsman

Job Description: Drafts wiring diagrams, schematics, and layout drawings used in manufacture, assembly, installation, and repair of electronic equipment, such as television cameras, radio transmitters and receivers, audioamplifiers, computers, and radiation detectors, performing duties as described under Draftsman I. Drafts layout and detail drawings of racks, panels, and enclosures. May conduct service and interference studies and prepare maps and charts related to radio and television surveys. May be designated according to equipment drafted as Radio Draftsman (radio & tv broad.).

Percent of total drafting personnel surveyed in Texas who are employed in the above capacity (1969): 3.1%

Suggested Course of Study:

First Semester

(Common to all areas; see FORM II-C-4A, Aeronautical Draftsman, page 44.)

Second Semester

| | | |
|---|---|---|
| Technical Writing | | (3-0) 3 |
| Trigonometry | | (3-0) 3 |
| Shop Practice | | (2-4) 3 |
| Machine Drafting | | (2-4) 3 |
| Descriptive Geometry | | (2-4) 3 |
| Electronic Technology | | (3-0) 3 |
| Physical Education II | | R |
| | TOTAL | (15-12) 18 |

## FORM II-C-4F--Continued

### Third Semester

| | | |
|---|---|---|
| Physics I | | (3-4) 4 |
| Electrical & Electronic Drafting | | (2-4) 3 |
| Structural Drafting I | | (2-4) 3 |
| Technical Illustration I | | (2-4) 3 |
| Science or Math Elective: | | |
| ______________________________ | | (3-0) 3 |
| | TOTAL | (12-16) 16 |

### Fourth Semester

| | | |
|---|---|---|
| Physics II | | (3-4) 4 |
| Sheet Metal Drafting | | (2-4) 3 |
| Social Studies Elective: | | |
| ______________________________ | | (3-0) 3 |
| General Elective: | | |
| ______________________________ | | ( ) 3 |
| General Elective: | | |
| ______________________________ | | ( ) 3 |
| | TOTAL | ( ) 16 |

FORM II-C-4G EXAMPLE
(NOT OFFERED)

Job Title: Map Draftsman

Job Description: Draws maps of cities, counties, States, and other areas showing location and identity of roads, communities, commercial or industrial structures and installations, political boundaries, and other features, performing duties as described under Draftsman I: Analyzes survey data, reference maps, and other records to determine location of features, such as primary or secondary roads, overhead powerlines, underground pipelines, oil wells, and railroad tracks. Studies deeds, leases, statutes, and other legal records to establish boundary lines of cities, boroughs, States, counties, districts, regions, and other politically, socially, or economically determined areas. May originate and revise maps related to commercial or industrial property or contracts and be designated Records Draftsman. Maps concerned with representation of topographical or subsurface geological data are drawn by Geological Draftsman (petrol. production) and Topographical Draftsman.

The above description also fits the following titles: Cartographer, Map Maker, Mapper.

Percent of total drafting personnel surveyed in Texas who are employed in the above capacity (1969): 7.7%

Suggested Course of Study:

First Semester

(Common to all areas; see FORM II-C-4A, Aeronautical Draftsman, page 44 .)

## FORM II-C-4G--Continued

### Second Semester

| | | |
|---|---|---|
| Technical Writing | | (3-0) 3 |
| Trigonometry | | (3-0) 3 |
| Shop Practice | | (2-4) 3 |
| Machine Drafting | | (2-4) 3 |
| Descriptive Geometry | | (2-4) 3 |
| Surveying | | (3-0) 3 |
| Physical Education II | | R |
| | TOTAL | (15-12) 18 |

### Third Semester

| | | |
|---|---|---|
| Physics I | | (3-4) 4 |
| Electrical & Electronic Drafting | | (2-4) 3 |
| Structural Drafting I | | (2-4) 3 |
| Technical Illustration I | | (2-4) 3 |
| Science or Math Elective: | | |
| ______________________________ | | (3-0) 3 |
| | TOTAL | (12-16) 16 |

### Fourth Semester

| | | |
|---|---|---|
| Physics II | | (3-4) 4 |
| Map & Topographic Drafting | | (2-4) 3 |
| Social Studies Elective: | | |
| ______________________________ | | (3-0) 3 |
| General Elective: | | |
| ______________________________ | | (     ) 3 |
| General Elective: | | |
| ______________________________ | | (     ) 3 |
| | TOTAL | (     ) 16 |

FORM II-C-4H

EXAMPLE

Job Title: Mechanical Draftsman

Job Description: Performs duties of Draftsman I specializing in drafting detailed working drawings of machinery and mechanical devices, indicating dimensions and tolerances, fasteners and joining requirements, and other engineering data. Drafts multiple-view assembly and subassembly drawings as required for manufacture and repair of mechanisms.

Percent of total drafting personnel surveyed in Texas who are employed in the above capacity (1969): 22.0%

Suggested Course of Study:

First Semester

(Common to all areas; see FORM II-C-4A, Aeronautical Draftsman, page 44.)

Second Semester

| | | |
|---|---|---|
| Technical Writing | | (3-0) 3 |
| Trigonometry | | (3-0) 3 |
| Shop Practice | | (2-4) 3 |
| Machine Drafting | | (2-4) 3 |
| Descriptive Geometry | | (2-4) 3 |
| Computer Programming | | (3-0) 3 |
| Physical Education II | | R |
| | TOTAL | (15-12) 18 |

FORM II -C-4H--Continued

### Third Semester

| | |
|---|---|
| Physics I | (3-4) 4 |
| Electrical & Electronic Drafting | (2-4) 3 |
| Structural Drafting I | (2-4) 3 |
| Technical Illustration I | (2-4) 3 |
| Analytic Geometry | (3-0) 3 |
| TOTAL | (12-16) 16 |

### Fourth Semester

| | |
|---|---|
| Physics II | (3-4) 4 |
| Machine & Tool Drafting | (2-4) 3 |
| Social Studies Elective: | |
| HISTORY OR GOV'T. | (3-0) 3 |
| General Elective: | |
| (STUDENT SELECTED) | ( ) 3 |
| General Elective: | |
| (STUDENT SELECTED) | ( ) 3 |
| TOTAL | ( ) 16 |

FORM II-C-4I EXAMPLE
(NOT OFFERED)

Job Title: Oil & Gas (Piping) Draftsman

Job Description: Drafts plans and drawings for layout, construction, and operation of oil fields, refineries, and pipeline systems from field notes, rough or detailed sketches, and specifications: Develops detail drawings for construction of equipment and structures, such as drilling derricks, compressor stations, gasoline plants, frame, steel, and masonry buildings, piping manifolds and pipeline systems, and for manufacture, fabrication, and assembly of machines and machine parts. Prepares maps of pipeline systems and oil and gas locations, using field survey notes and aerial photographs. May draft topographical maps, or develop maps to represent geological stratigraphy and locations of oil and gas deposits, using geological and geophysical prospecting and surveying data.

Percent of total drafting personnel surveyed in Texas who are employed in the above capacity (1969): 9.7%

Suggested Course of Study:

First Semester

(Common to all areas; see FORM II-C-4A,
Aeronautical Draftsman, page 44 .)

Second Semester

| | | |
|---|---|---|
| Technical Writing | | (3-0) 3 |
| Trigonometry | | (3-0) 3 |
| Shop Practice | | (2-4) 3 |
| Machine Drafting | | (2-4) 3 |
| Descriptive Geometry | | (2-4) 3 |
| Surveying | | (3-0) 3 |
| Physical Education | | R |
| | TOTAL | (15-12) 18 |

## FORM II-C-4I--Continued

### Third Semester

| | | |
|---|---|---|
| Physics I | | (3-4) 4 |
| Electrical & Electronic Drafting | | (2-4) 3 |
| Structural Drafting I | | (2-4) 3 |
| Pipe & Vessel Detailing | | (2-4) 3 |
| Chemistry | | (3-0) 3 |
| | TOTAL | (12-16) 16 |

### Fourth Semester

| | | |
|---|---|---|
| Physics II | | (3-4) 4 |
| Map & Topographic Drafting | | (2-4) 3 |
| Social Studies:<br>____________________ | | (3-0) 3 |
| General Elective:<br>____________________ | | (    ) 3 |
| General Elective:<br>____________________ | | (    ) 3 |
| | TOTAL | (    ) 16 |

FORM II-C-4J

EXAMPLE

Job Title: Structural Draftsman

Job Description: Performs duties of Draftsman I by drawing plans for structures employing structural steel, such as bridge trusses, plate girders, roof trusses, trestle bridges and columns, and other integral parts. Makes drawings for masonry or timber members.

Percent of total drafting personnel surveyed in Texas who are employed in the above capacity (1969): 13.3%

Suggested Course of Study:

First Semester

(Common to all areas; see FORM II-C-4A, Aeronautical Draftsman, page 44.)

Second Semester

| | |
|---|---|
| Technical Writing | (3-0) 3 |
| Trigonometry | (3-0) 3 |
| Shop Practice | (2-4) 3 |
| Machine Drafting | (2-4) 3 |
| Descriptive Geometry | (2-4) 3 |
| Engineering Technology Elective: SURVEYING, AERO. TECHNOLOGY, OR COMPUTER PROGRAMMING, | (3-0) 3 |
| Physical Education II | R |
| TOTAL | (15-12) 18 |

FORM II-C-4J--Continued

### Third Semester

| | |
|---|---|
| Physics I | (3-4) 4 |
| Electrical & Electronic Drafting | (2-4) 3 |
| Structural Drafting I | (2-4) 3 |
| Analytic Geometry | (3-0) 3 |
| Drafting Elective:<br>Tech. Illustration, Computer Graphics, Sheet Metal Drafting, Etc. | (2-4) 3 |
| TOTAL | (12-16) 16 |

### Fourth Semester

| | |
|---|---|
| Physics II | (3-4) 4 |
| Structural Drafting II | (2-4) 3 |
| Social Studies Elective:<br>History or Gov't. | (3-0) 3 |
| General Elective:<br>(Student Selected) | ( ) 3 |
| General Elective:<br>(Student Selected) | ( ) 3 |
| TOTAL | ( ) 16 |

FORM II-C-4K EXAMPLE (NOT OFFERED)

Job Title: Technical Illustrator

Job Description: Lays out and draws illustrations for reproduction in reference works, brochures, and technical manuals dealing with assembly, installation, operation, maintenance, and repair of machines, tools, and equipment: Prepares drawings from blueprints, designs, mockups, and photoprints by methods and techniques suited to specified reproduction process or final use, such as blueprint, photo-offsett, and projection transparencies, using drafting and optical equipment. Lays out and draws schematic perspective, orthographic, or oblique-angle views to depict function, relationship, and assembly sequence of parts and assemblies, such as gears, engines, and instruments. Shades or colors drawing to emphasize details or to eliminate undesired background, using ink, crayon, airbrush, and overlays. Pastes instructions and comments in position on drawing. May draw cartoons and caricatures to illustrate operation, maintenance, and safety manuals and posters.

The above description also fits the following titles: Engineering Illustrator, Production Illustrator.

Percent of total drafting personnel surveyed in Texas who are employed in the above capacity (1969): 4.4%

Suggested Course of Study:

First Semester

(Common to all areas; see FORM II-C-4A, Aeronautical Draftsman, page 44 .)

FORM II-C-4K--Continued

### Second Semester

| | | |
|---|---|---|
| Technical Writing | | (3-0) 3 |
| Trigonometry | | (3-0) 3 |
| Shop Practice | | (2-4) 3 |
| Machine Drafting | | (2-4) 3 |
| Descriptive Geometry | | (2-4) 3 |
| Engineering Technology Elective: | | |
| ________________________________ | | (3-0) 3 |
| Physical Education II | | R |
| | TOTAL | (15-12) 18 |

### Third Semester

| | | |
|---|---|---|
| Physics I | | (3-4) 4 |
| Electrical & Electronic Drafting | | (2-4) 3 |
| Structural Drafting I | | (2-4) 3 |
| Technical Illustration I | | (2-4) 3 |
| Analytic Geometry | | (3-0) 3 |
| | TOTAL | (12-16) 16 |

### Fourth Semester

| | | |
|---|---|---|
| Physics II | | (3-4) 4 |
| Technical Illustration II | | (2-4) 3 |
| Social Studies Elective: | | |
| ________________________________ | | (3-0) 3 |
| General Elective: | | |
| ________________________________ | | (   ) 3 |
| General Elective: | | |
| ________________________________ | | (   ) 3 |
| | TOTAL | (   ) 16 |

FORM II-C-4L EXAMPLE

(Not Offered)

Job Title: Tool Design Draftsman

Job Description: Same description as Mechanical Draftsman with the addition of the following: Specializes in drawing plans for manufacture of tools, usually following designs and specifications in indicated by Tool Designer.

Percent of total drafting personnel surveyed in Texas who are employed in the above capacity (1969): 3.1%

Suggested Course of Study:

### First Semester

(Common to all areas; see FORM II-C-4A, Aeronautical Draftsman, page 44 .)

### Second Semester

| | | |
|---|---|---|
| Technical Writing | | (3-0) 3 |
| Trigonometry | | (3-0) 3 |
| Shop Practice | | (2-4) 3 |
| Machine Drafting | | (2-4) 3 |
| Descriptive Geometry | | (2-4) 3 |
| Computer Programming | | (3-0) 3 |
| Physical Education II | | R |
| | TOTAL | (15-12) 18 |

### Third Semester

| | | |
|---|---|---|
| Physics I | | (3-4) 4 |
| Electrical & Electronic Drafting | | (2-4) 3 |
| Structural Drafting I | | (2-4) 3 |
| Technical Illustration I | | (2-4) 3 |
| Analytic Geometry | | (3-0) 3 |
| | TOTAL | (12-16) 16 |

FORM II-C-4L--Continued

Fourth Semester

| | | |
|---|---|---|
| Physics II | | (3-4) 4 |
| Machine & Tool Drafting | | (2-4) 3 |
| Social Studies Elective: | | |
| ____________________ | | (3-0) 3 |
| General Elective: | | |
| ____________________ | | ( ) 3 |
| General Elective: | | |
| ____________________ | | ( ) 3 |
| | TOTAL | ( ) 16 |

# DRAFTING COURSE OUTLINES

## Topical Outlines of Drafting Courses

The outlines on the following pages reflect for each course a composite of relative topic importance as assessed by both the schools and the industries surveyed.

It must be made clear that the outlines do not necessarily represent teaching schedules, lesson plans, or sequences of topics. They are intended to serve primarily as lists of topics around which each course may be constructed with the emphasis to be placed on each topic indicated by the number of clock hours devoted to each, both for theory (lecture) and practice (laboratory). The authors believe that presenting the material in this manner permits the greatest flexibility for individual schools, departments and teachers to design their own courses while still maintaining a consistency of subject matter.

It is quite likely that program planners will detect some overlapping and repetition of topics listed; some modification of hours devoted to the various topics may therefore be necessary. It is not the intent to present the topics as being necessarily distinct from one another, but rather to state them as being worthy of consideration when preparing a course plan. The lecture-laboratory hours breakdown was selected as a convenient way of indicating the weight that each items should receive in the overall course structure.

It is expected that each school will engage instructors competent to teach the various courses. Since instructors tend to feel more confident teaching courses they have helped to plan, it is recommended that they be given the opportunity, if not the responsibility of setting up specific course schedules based upon the outlines given here.

## Aeronautical Drafting (2-4) 3

A course designed for drafting students who will enter the aircraft/aerospace industry. Particular emphasis on drafting practices concerned with airframe structures and materials, and the requirements of the aerodynamic-structural-mechanical system. Modern techniques and materials peculiar to draft operating outside the earth's atmosphere and gravitational field.

| Topic | Lecture | Laboratory |
|---|---|---|
| 1. Aircraft nomenclature | 2 | 5 |
| a. Basic parts | | |
| (1) fuselage | | |
| (2) wings | | |
| (3) empennage | | |
| (4) engines and nacelles | | |
| (5) fairings | | |
| b. Control surfaces | | |
| (1) ailerons | | |
| (2) elevator | | |
| (3) rudder | | |
| (4) flaps | | |
| (5) trim tabs | | |
| (6) spoilers | | |
| c. Landing gear | | |
| (1) types | | |
| (2) retraction | | |
| (3) cover doors | | |
| 2. Principles of flight | 1 | 1 |
| a. Forces | | |
| (1) lift | | |
| (2) drag | | |
| (3) thrust | | |
| (4) weight | | |
| (5) moments | | |

Aeronautical Drafting--Continued

b. Airfoils and wings
  (1) principle of lift
  (2) airfoil profiles
  (3) chord
  (4) camber
  (5) aspect ratio
  (6) dihedral
  (7) taper
  (8) wash-out
  (9) sweep-back

3. Mechanisms and linkages 3 6

a. Types of motion
  (1) straight-line
  (2) rotary
  (3) curvilinear
  (4) plane motion
  (5) space motion
b. Mechanisms
  (1) rod and bar
  (2) sliding
  (3) pivots and bellcranks
  (4) gears
  (5) cams
c. Motion transfer
  (1) straight-to-rotary
  (2) rotary-to-straight
  (3) plane-to-plane
  (4) plane-to-space
  (5) combinations

4. Airframe structure 3 6

a. Wings
  (1) main spars
  (2) ribs
  (3) stringers

## Aeronautical Drafting--Continued

- (4) control surfaces
- (5) skins and coverings
- (6) loading and support

b. Fuselages
- (1) main frame
- (2) formers and bulkheads
- (3) longeroses
- (4) wing and landing gear support
- (5) skins and coverings
- (6) non-structural openings
- (7) monocoque design

c. Engines
- (1) nacelle frames
- (2) engine mounts and supports
- (3) coverings
- (4) access panels

| | | |
|---|---|---|
| 5. Aerodynamic surfaces | 1 | 2 |

a. Aerodynamic requirements
- (1) form and location
- (2) smoothness

b. Structural requirements
- (1) rigidity
- (2) flexibility
- (3) strength

| | | |
|---|---|---|
| 6. Aircraft structural materials | 4 | 6 |

a. Types of materials
- (1) steel alloys
- (2) aluminum alloys
- (3) titanium alloys
- (4) magnesium alloys
- (5) reinforced plastics

b. Comparison of materials
- (1) strength
- (2) weight
- (3) elasticity
- (4) material cost

Aeronautical Drafting--Continued

(5) labor cost
(6) relative cost
c. Types of fabrication
(1) bolting and riveting
(2) welding
(3) adhesive bonding
(4) extruding
(5) rolling
(6) casting
(7) forging
(8) machining

7. Fasteners 3 6

a. Rivets
(1) materials
(2) head types
(3) driving
(4) shear and tensile strength
(5) sizes
b. Bolts
(1) materials
(2) tightening
(3) shear and tensile strength
(4) sizes
c. Joint design
(1) lap joints
(2) single and double shear
(3) tension joints
(4) moment connections
(5) load distribution
(6) hole sizes

8. Adhesives 2 5

a. Types
(1) film
(2) liquid

Aeronautical Drafting--Continued

    - (3) foam
    - (4) putties and fillers
- b. Bonding processes
    - (1) surface preparation
    - (2) application
    - (3) bonding operation
- c. Structural properties
    - (1) sandwich construction
    - (2) column behavior
    - (3) static strength
    - (4) honeycomb structure
    - (5) temperature strength
    - (6) fatigue characteristics
- d. Bonded structure design
    - (1) panels
    - (2) stress analysis
    - (3) detail design
- e. Tooling
    - (1) equipment
    - (2) press bonding
    - (3) autoclave bonding
- f. Inspection
    - (1) process control
    - (2) non-destructive inspection

| | | | |
|---|---|---|---|
| 9. | Electrical and hydraulic systems | 1 | 1 |

- a. Routing and layout
- b. Control and metering devices
- c. Schematic and block diagrams
- d. Symbols

| | | | |
|---|---|---|---|
| 10. | Fuel system layout | 1 | 1 |

- a. Pipeline routing
- b. Tank location and construction
- c. Pumps and control devices
- d. Symbols

Aeronautical Drafting--Continued

11. Military Specifications 2 5

   a. General
      (1) MIL-STD-100, engineering drawing practices
      (2) MIL-STD-8C, dimensioning and tolerancing
   b. Special
      (1) MIL-STD-12, abbreviations
      (2) MIL-STD-16, electrical-electronic symbols
      (3) MIL-STD-17, mechanical symbols
      (4) MIL-STD-18, structural symbols
      (5) MIL-STD-23, nondestructive symbols

12. Drafting room manuals 4 7

(It is suggested that manuals be obtained from nearby aerospace industries, and studied under the instructor's guidance. If possible, manuals from difficult firms should be obtained so that common procedures and differences can be observed. Most companies will also provide samples of production drawings upon request.)

13. Landing gear systems 1 3

   a. Gear arrangement
   b. Tires and wheels
   c. Shock absorbers
   d. Design of primary members

Aeronautical Drafting--Continued

| | | |
|---|---|---|
| 14. Flight control systems | 1 | 3 |
| a. Manual systems | | |
| (1) linkage and cable mechanisms | | |
| (2) forces required | | |
| b. Hydraulic systems | | |
| (1) pumps and controls | | |
| (2) piping and fixtures | | |
| (3) forces required | | |
| 15. Power plant considerations | 1 | 3 |
| a. Wing-mounted engines | | |
| (1) location | | |
| (2) forces | | |
| (3) structural requirements | | |
| b. Fuselage-mounted engines | | |
| (1) location | | |
| (2) forces | | |
| (3) structural requirements | | |
| c. Pod-mounted engines | | |
| 16. Scribe-coat materials | 2 | 4 |
| a. Materials | | |
| (1) base materials | | |
| (2) scribe-coat | | |
| (3) peel-coat | | |
| b. Tools and scribers | | |
| (1) configuration | | |
| (2) cutter tip sizes | | |
| c. Automated drawing | | |
| (1) numerically-controlled platters | | |
| (2) program control | | |
| TOTALS | 32 | 64 |

Aeronautical Drafting--Continued

Suggested Texts:

(No formal texts are being used where this course is being taught; reference materials from the aerospace industry supplied by instructors, and Military Standards MIL-STD 100 and D-1000 are used.)

Additional Recommended References:

Wood, Aerospace Vehicle Design, Vol I--Aircraft Design, 1963, Johnson Publishing Co.

Special Equipment or Facilities Recommended:

Drafting manuals and sample production drawings from nearby aerospace industries.

Samples of scribe- and peel-coat materials and scribers.

Opportunity to visit aerospace company drafting and design department would be beneficial.

## Basic Drafting (2-4) 3

An introductory course in drafting emphasizing fundamental knowledge and skills required for fluency in graphical communication. Considerable time spent on developing proper techniques and habits in drafting ability through practice. Skills obtained in this course are prerequisite for and common to all drafting areas.

| Topic* | Lecture | Laboratory |
|---|---|---|
| 1. Drawing equipment and instruments | 2 | 3 |
| a. Pencils | | |
| b. Triangles | | |
| c. Irregular curves | | |
| d. Drafting machine or T-square | | |
| e. Compasses and dividers | | |
| f. Drawing media | | |
| g. Templates | | |
| 2. Freehand lettering | 1 | 5 |
| a. Engineering styles | | |
| b. Architectural and other styles | | |
| c. Composition and proportion | | |
| d. Guide lines | | |
| e. Lettering instruments | | |
| (1) Ames, Braddock-Rowe | | |
| (2) mechanical lettering | | |
| 3. Standard line symbols | 2 | 4 |
| a. The alphabet of lines | | |
| b. Line weight vs pencil grade | | |
| c. Straight vs curved lines | | |

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*Listed in approximate order of presentation; however, topics may overlap or be rearranged at the discretion of the user.

Basic Drafting--Continued

| | Topic | Lecture | Laboratory |
|---|---|---|---|
| 4. | Use of scales | 2 | 3 |
| | a. Architect's scale | | |
| | b. Civil engineer's scale | | |
| | c. Mechanical engineer's scale | | |
| 5. | Geometric construction | 2 | 5 |
| | a. Accuracy and line weight | | |
| | b. Parallels and perpendiculars | | |
| | c. Angles | | |
| | d. Tangencies | | |
| | e. Subdividing lines and arcs | | |
| | f. Copying figures | | |
| 6. | Multiview drawing | 3 | 5 |
| | a. Orthographic projection | | |
| | b. Principle views | | |
| | c. Hidden lines | | |
| | d. Circular features | | |
| | e. Center lines | | |
| | f. Visibility | | |
| | g. Drawing layout | | |
| 7. | Primary auxiliary views | 2 | 4 |
| | a. Reference planes | | |
| | b. True shape of surfaces | | |
| | c. Projection of curves | | |
| 8. | Secondary auxiliary views | 1 | 3 |
| | a. Reference planes | | |
| | b. True shape of surfaces | | |
| | c. Pictorial views | | |

Basic Drafting--Continued

| Topic | Lecture | Laboratory |
|---|---|---|
| 9. Basic dimensioning | 2 | 4 |
| a. Standard techniques | | |
| (1) dimension and extension lines | | |
| (2) arrowheads | | |
| (3) spacing | | |
| (4) notes and leaders | | |
| b. Linear and angular dimensions | | |
| c. Selection and placement | | |
| 10. Isometric drawing | 2 | 4 |
| a. Position of axes | | |
| b. Projection *vs* drawing | | |
| c. Ellipses | | |
| (1) four-center ellipse | | |
| (2) ellipse guides | | |
| d. Angles and curves | | |
| 11. Oblique drawing | 2 | 4 |
| a. Oblique *vs* orthographic | | |
| b. Position of axes | | |
| c. Placement of object | | |
| d. Angles and curves | | |
| 12. Perspective drawing | 1 | 1 |
| a. Perspective *vs* orthographic | | |
| b. Picture plane, ground line and horizon | | |
| c. Station point and vanishing points | | |
| d. One- and two-point perspective | | |
| e. Curves in perspective | | |
| 13. Sections and conventions | 2 | 4 |
| a. Sections | | |
| (1) purpose | | |

## Basic Drafting--Continued

| Topic | Lecture | Laboratory |
|---|---|---|
| (2) cutting planes | | |
| (3) section lines | | |
| (4) types | | |
| b. Conventional practices | | |
| (1) reasons | | |
| (2) violations of projection | | |
| (3) rotation of parts | | |
| (4) use with sections | | |
| c. Dimensioning with sections | | |
| 14. Threads and fasteners | 1 | 3 |
| a. Thread types | | |
| b. Thread symbols and notes | | |
| c. Use of thread tables | | |
| d. Fasteners | | |
| (1) nuts and bolts | | |
| (2) rivets and pins | | |
| 15. Tolerancing | 1 | 2 |
| a. Purpose | | |
| b. Terminology | | |
| (1) tolerance | | |
| (2) allowance | | |
| (3) clearance | | |
| (4) interference | | |
| c. Limits | | |
| d. Classes of fit | | |
| e. Use of tables | | |
| f. Positional tolerancing | | |
| g. Tolerances of form | | |
| e. Standards | | |
| 16. Working drawings | 2 | 3 |
| a. Detail drawings | | |
| (1) parts and material identification | | |

## Basic Drafting--Continued

| | Topic | Lecture | Laboratory |
|---|---|---|---|
| | (2) title layout | | |
| | b. Assembly drawings | | |
| | (1) parts list | | |
| | (2) parts identification | | |
| | (3) use of pictorials and sections | | |
| | (4) exploded assemblies | | |
| 17. | Freehand sketching | 1 | 3 |
| | a. Uses | | |
| | b. Techniques | | |
| 18. | Charts and graphs | 1 | 1 |
| | a. Types | | |
| | (1) bar | | |
| | (2) line | | |
| | (3) percentage | | |
| | b. Identification | | |
| | (1) title | | |
| | (2) scales | | |
| | (3) legend | | |
| | c. Printed papers | | |
| 19. | Drawing reproduction | 1 | 2 |
| | a. Quality of original | | |
| | b. Blue line prints | | |
| | c. Microfilming | | |
| | d. Computerization | | |
| 20. | Intersection and developments | 1 | 1 |
| | a. Parallel-line development | | |
| | b. Radial-line development | | |
| | c. Triangulation | | |
| | d. Gore and zone methods | | |
| | TOTALS | 32 | 64 |

Basic Drafting--Continued

Suggested Texts:

Arnold, Introductory Graphics, 1958, McGraw-Hill.

Earle, Engineering Design Graphics, 1969, Addison-Wesley.

French and Vierck, Graphic Science, 2nd Ed., 1963, McGraw-Hill.

Giesecke, Mitchell, Spencer, Hill and Loving, Engineering Graphics, 1969, Macmillan.

Hammond, et al., Engineering Graphics, 1964, Ronald.

Luzadder, Basic Graphics, 1968, Prentice-Hall.

Rising and Almfeldt, Engineering Graphics, 1964, Brown.

Svensen and Street, Engineering Graphics, 1962, Van Nostrand.

Wellman, Introduction to Graphical Analysis and Design, 1966, McGraw-Hill.

Additional Recommended References:

ANSI Engineering Drawing Standards

Special Equipment or Facilities Recommended:

Drafting machines for student use.

Chalkboard drafting machine.

Diazo (blue-line) process print reproduction machine.

## Building Construction Drafting I (2-4) 3

A first course in architectural drafting, introducing conventional techniques and methods used to represent building structures and their specifications. Intended to enable the draftsman to recognize and handle a building structure as a part of an overall engineering system.

| Topic | Lecture | Laboratory |
|---|---|---|
| 1. History of architecture | 1 | 1 |
| a. Ancient | | |
| b. Renaissance | | |
| c. American | | |
| 2. Styles of architecture | 2 | 1 |
| a. Classic | | |
| b. Contemporary | | |
| 3. Architectural symbols | 2 | 5 |
| a. Materials | | |
| b. Construction details | | |
| c. Electrical symbols | | |
| d. Plumbing symbols | | |
| 4. Architectural lettering | 2 | 5 |
| a. Styles | | |
| b. Proportion | | |
| c. Spacing | | |
| d. Mechanical *vs*. freehand | | |
| e. Title composition | | |

Building Construction Drafting I--Continued

| | | |
|---|---|---|
| 5. Standard building construction | 3 | 7 |
| a. Foundations | | |
| (1) ground preparation | | |
| (2) footings | | |
| (3) foundation walls | | |
| (4) sills and joists | | |
| (5) slabs | | |
| b. Framing | | |
| c. Finishes | | |
| (1) exterior | | |
| (2) interior | | |
| 6. Area planning | 1 | 3 |
| a. Preliminary planning | | |
| (1) lot orientation | | |
| (2) building placement | | |
| (3) style, shape and size | | |
| b. Building layout | | |
| (1) orientation and size of rooms | | |
| (2) heating, plumbing and lighting | | |
| 7. Site plans | 2 | 3 |
| a. Property lines | | |
| b. Easements | | |
| c. Natural features and topography | | |
| d. Setback | | |
| 8. Floor plans | 2 | 6 |
| a. Interior and exterior wall symbols | | |
| b. (1) single-line | | |
| (2) double-line | | |
| b. Doors and windows | | |
| c. Plumbing and electrical symbols | | |

## Building Construction Drafting I--Continued

| | | |
|---|---|---|
| 9. Elevations | 2 | 4 |
| a. Symbols | | |
| b. Standard sizes | | |
| (1) floor height | | |
| (2) windows | | |
| (3) doors | | |
| 10. Sections | 2 | 5 |
| a. Full | | |
| b. Half or partial | | |
| c. Longitudinal | | |
| d. Material symbols | | |
| 11. Pictorials | 1 | 2 |
| a. Axonometric | | |
| b. Oblique | | |
| 12. Perspective | 1 | 3 |
| a. One-point | | |
| b. Two-point | | |
| c. Three-point | | |
| d. Exteriors | | |
| e. Interiors | | |
| f. Perspective grids | | |
| 13. Schedules, codes and specifications | 2 | 3 |
| a. Schedules | | |
| (1) door | | |
| (2) window | | |
| (3) room | | |
| b. Building codes | | |
| (1) footings and foundations | | |
| (2) zoning | | |

Building Construction Drafting I--Continued

    (3) deed restrictions
    (4) easements
    (5) covenants

14. Electrical, plumbing and heating 2 3

- a. Electrical
    - (1) planning
    - (2) wiring plans
    - (3) placement of symbols
- b. Plumbing
    - (1) planning
    - (2) fixture specification
    - (3) symbols
- c. Heating and cooling
    - (1) regulation and loss
    - (2) system design
    - (3) symbols

15. Cost estimating 1 2

- a. Building site
    - (1) lot
    - (2) utility improvements
- b. Building construction
    - (1) excavation
    - (2) basic shell
    - (3) standard equipment and fixtures
    - (4) special fixtures
    - (5) fees, permits, licenses and insurance

16. Modular construction 1 3

- a. Advantages and limitations
- b. Standard dimensional units
- c. Modular design

Building Construction Drafting I--Continued

17. Door and window details 2 3
    - a. Doors
        - (1) sizes and types
        - (2) framing
        - (3) symbols
    - b. Windows
        - (1) sizes and types
        - (2) framing and sash
        - (3) glazing
        - (4) symbols

18. Shade and shadow 1 1
    - a. Standard light source
    - b. In plans and elevations
    - c. In perspective
    - d. Methods

19. Rendering
    - a. Pencil 1 2
        - (1) line shading
        - (2) smudge shading
        - (3) representation of materials and flora
    - b. Ink
        - (1) line shading
        - (2) cross-hatching
        - (3) representation of materials and flora
    - c. Paint
        - (1) water color and wash
        - (2) tempera
    - d. Other media
        - (1) shading films
        - (2) transfer symbols

Building Construction Drafting I--Continued

| | | 1 | 2 |
|---|---|---|---|
| 20. | Landscaping | 1 | 2 |
| | a. Utilization of existing features | | |
| | b. Relation to area planning | | |
| | c. Aesthetics | | |
| | d. Contribution to comfort and temperature control | | |
| | e. Landscaping plans and elevations | | |
| | TOTALS | 32 | 64 |

Suggested Texts:

Hornung, Architectural Drafting, 4th Edition, 1966, Prentice-Hall

Martin, Architectural Graphics, 1952, Macmillan

Muller, Architectural Drawing and Light Construction, 1967, Prentice-Hall

Ray, Graphic Architectural Drafting Rev. Ed., 1960, McKnight

Spence, Architecture: Design--Engineering--Drawing, 1967, McKnight

Stegman and Stegman, Architectural Drafting; Functional Planning and Creative Design, 1970, American Technical Society

Additional Recommended References:

Benson, Building Contractor's and Home Builder's Handbook of Bidding, Surveying, and Estimating, 1968, Prentice-Hall

Burke and Buss, Architectural Lettering for Plans and Ornamental Design, 1970, American Technical Society

Burke, Dalzell and Townsend, Architectural and Building Trades Dictionary, 1970, American Technical Society

Building Construction Drafting I--Continued

Additional Recommended References--Continued:

Dahl and Wilson, Cabinet Making and Millwork: Tools, Materials, Layout, Construction, 1970, American Technical Society

Oberg, Heavy Timber Construction, 1970, American Technical Society

Steinberg and Stempel, Estimating for the Building Trades, 1970, American Technical Society

Townsend, Dalzell and Battenburg, How to Plan a House, 1970, American Technical Society

## Building Construction Drafting II (2-4) 3

A continuation of Building Construction Drafting I, designed for students who wish to specialize in architectural drafting. Additional emphasis placed on building codes and specifications, modern construction methods, and commercial building requirements. Analysis of building sites and mechanical systems within buildings.

| Topic | Lecture | Laboratory |
|---|---|---|
| 1. Schedules, codes and specifications | 3 | 6 |
| a. Schedules | | |
| (1) door | | |
| (2) window | | |
| (3) room | | |
| (4) others | | |
| b. Building codes | | |
| (1) footings and foundations | | |
| (2) zoning | | |
| (3) deed restrictions | | |
| (4) easements | | |
| (5) covenants | | |
| (6) others | | |
| 2. Electrical wiring | 2 | 4 |
| a. Electricity and site selection | | |
| b. Planning circuits | | |
| (1) wiring layout | | |
| (2) conduits and terminal boxes | | |
| (3) symbols | | |
| c. Checking | | |
| (1) plans | | |
| (2) electrical equipment check lists | | |

## Building Construction Drafting II--Continued

| | | |
|---|---|---|
| 3. Plumbing | 2 | 4 |
| a. Planning layouts | | |
| b. Fixtures | | |
| (1) selection | | |
| (2) symbols | | |
| c. Water | | |
| d. Gas | | |
| e. Sewer | | |
| 4. Ducting | 2 | 3 |
| a. Heating and air conditioning | | |
| b. System types | | |
| (1) individual | | |
| (2) trunk | | |
| c. Registers | | |
| d. Fans and blowers | | |
| e. Filters | | |
| f. Humidifiers | | |
| g. Controls | | |
| 5. Modular construction | 3 | 5 |
| a. Advantages and limitations | | |
| b. Standard dimensional unit | | |
| c. Modular design | | |
| (1) grid layouts | | |
| (2) coordination with available materials | | |
| 6. Cost estimating | 2 | 3 |
| a. Building site | | |
| (1) lot | | |
| (2) utility improvements | | |
| b. Building construction | | |
| (1) excavation | | |
| (2) basic frame | | |
| (3) standard equipment and fixtures | | |

Building Construction Drafting II--Continued

    (4) special fixtures
    (5) fees, permits, licenses and insurance

7. Millwork drawings 0 3

  a. Standard trim moldings
  b. Use of manufacturers' catalogs

8. Built-in equipment 1 3

  a. In exterior walls
    (1) fireplaces and flues
    (2) utility meters
  b. In partitions
    (1) kitchen and bathroom accessories
    (2) oven and refrigerator
    (3) washing machine and dryer
  c. Electrical supply, ducting and drainage
  d. Cabinets and bookcases
  e. Fuse or circuit-breaker boxes
  f. Bells, buzzers and intercoms
  g. Other custom equipment
    (1) TV or FM antenna
    (2) music system
    (3) central vaccuum cleaner
    (4) plug-in telephone wiring
    (5) incinerator
    (6) sauna bath

9. Landscaping 1 3

  a. Natural features of site
    (1) trees and other flora
    (2) topology and mineral formations
    (3) streams or lakes
  b. Relation to building position
    (1) aesthetics
    (2) comfort and climate control

Building Construction Drafting II--Continued

- (3) accessibility
- (4) construction clearance

c. Site modification
- (1) planting and harmony with building and existing site
- (2) floricultural and climatic considerations

10. Site analysis 2 4

a. Restrictions
- (1) building codes
- (2) zoning
- (3) deed restrictions, easements and covenants

b. Community characteristics
- (1) schools, churches, shopping
- (2) trees
- (3) street lighting
- (4) fire protection
- (5) water, sewer, gas and electricity
- (6) telephone service
- (7) waste disposal
- (8) mail service
- (9) public transportation
- (10) cable TV
- (11) parks and recreational facilities

c. Topography
- (1) surface conditions
- (2) soil conditions
- (3) ground water

d. Orientation of the site
- (1) facing the house
- (2) prevailing winds

e. Size of the plot

11. Commercial and non-residential buildings 2 4

a. Schools
b. Hospitals

- c. Retail stores
  - (1) individual
  - (2) department stores and supermarkets
- d. Garages and storage buildings
- e. Office buildings
- f. Multiple dwellings
- g. Civic buildings
  - (1) governmental offices
  - (2) fire and police stations

12. Structural drawings 3 5

- a. Footings and foundations
  - (1) concrete block
  - (2) poured concrete
  - (3) slabs and beams
  - (4) reinforcing
- b. Wood frame construction
  - (1) types
  - (2) details
  - (3) roof framing
  - (4) openings
  - (5) partitions and interior walls
  - (6) dormer and bay windows
  - (7) sills
  - (8) floors
- c. Masonry construction
  - (1) sheathing
  - (2) stucco
  - (3) brick
  - (4) stone
- d. Steel structures
  - (1) standard shapes
  - (2) beams and columns
  - (3) trusses
  - (4) prefabrication

Building Construction Drafting II--Continued

| | | |
|---|---|---|
| 13. Design problems | 3 | 5 |
| a. Individual projects<br>b. Group projects | | |
| 14. Field trips | 3 | 5 |
| a. Residential sites<br>b. Non-residential sites<br>c. Architectural offices | | |
| 15. Advanced rendering | 0 | 1 |
| a. Complete rendering of student design project or airbrush demonstration | | |
| 16. Zoning | 2 | 2 |
| a. Study of local zoning requirements<br>b. Invite local housing authority as guest speaker | | |
| 17. Environmental studies | 0 | 2 |
| a. Inspect and photograph local community areas<br>b. Discuss community areas<br>(1) ecology and environmental pollution<br>(2) coordination of building types | | |
| 18. Legal considerations | 1 | 2 |
| a. Documents<br>(1) agreement to buy<br>(2) title search<br>(3) deed<br>(4) title guarantee | | |

Building Construction Drafting II--Continued

b. Drawings
    (1) land survey
    (2) location plan
    (3) landscape plans

| | | |
|---|---|---|
| TOTALS | 32 | 64 |

Suggested Texts:

(See listing for Building Construction Drafting I, page 85)

## Descriptive Geometry (2-4) 3

Theory and applications of spatial geometry to graphical representation and analysis of engineering systems. Development of relations between fundamental geometric elements of points, lines, and surfaces, and the use of these elements in analyzing and solving problems in selected representative areas of engineering.

| Topic* | Lecture | Laboratory |
|---|---|---|
| 1. Orthographic projection | 3 | 5 |
| a. Review fundamentals | | |
| b. Projection of points, lines, planes | | |
| 2. Views of points, lines, planes | 3 | 6 |
| a. True length of a line | | |
| b. Point view of a line | | |
| c. Principal lines | | |
| d. Edge view of a plane | | |
| e. True shape of a plane | | |
| f. Applications | | |
| (1) bearing and slope of a line | | |
| (2) direction and slope of a plane | | |
| 3. Plane and line intersections | 6 | 9 |
| a. Piercing points | | |
| b. Plane intersections | | |
| 4. Parallelism and perpendicularity | 3 | 5 |
| a. Parallel lines | | |
| b. Line parallel to plane | | |
| c. Parallel planes | | |
| d. Perpendicular lines | | |
| e. Line perpendicular to plane | | |

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*See footnote, page .

## Descriptive Geometry--Continued

| Topic | Lecture | Laboratory |
|---|---|---|
| f. Perpendicular planes | | |
| 5. Skew lines | 2 | 4 |
| a. Shortest connector | | |
| (1) line method | | |
| (2) plane method | | |
| b. Level connector | | |
| c. Grade connector | | |
| 6. Dihedral angles | 2 | 5 |
| a. Point view of line of intersection | | |
| b. Perpendicular line method | | |
| 7. Angle between a line and a plane | 2 | 6 |
| a. Triple auxiliary view method | | |
| b. Perpendicular plane method | | |
| 8. Revolution | 3 | 4 |
| a. Fundamental concepts | | |
| (1) axis of revolution | | |
| (2) path of revolved point | | |
| b. Revolution of a point | | |
| c. Revolution of a line | | |
| d. Revolution of a plane | | |
| e. Applications | | |
| (1) true length of a line | | |
| (2) slope of a line | | |
| (3) true shape of a plane | | |
| (4) angle between line and plane | | |
| (5) cone locus problem | | |
| (6) clearances | | |
| 9. Intersection and development | 2 | 5 |

## Descriptive Geometry--Continued

| Topic | Lecture | Laboratory |
|---|---|---|
| a. Intersection | | |
| (1) review fundamentals | | |
| (2) piercing point methods | | |
| (3) cutting plane methods | | |
| (4) cutting sphere methods | | |
| b. Developments | | |
| (1) parallel-line | | |
| (2) radial-line | | |
| (3) triangulation | | |
| (4) gore and zone | | |
| (5) transition pieces | | |
| 10. Charts and graphs | 0 | 2 |
| a. Technical graphs | | |
| b. Design selection graphs | | |
| 11. Graphical mathematics | 0 | 2 |
| a. Arithmetic operations | | |
| b. Squares and square roots | | |
| c. Trigonometric functions | | |
| 12. Vector graphics | 2 | 3 |
| a. Coplanar systems | | |
| (1) parallelogram law | | |
| (2) vector polygon | | |
| b. Parallel systems | | |
| (1) Bow's notation | | |
| (2) string and funicular polygons | | |
| c. Concurrent systems | | |
| (1) tripod structures | | |
| d. Beams and trusses | | |
| (1) Maxwell diagram | | |
| 13. Linkage analysis | 0 | 2 |

## Descriptive Geometry--Continued

| | Topic | Lecture | Laboratory |
|---|---|---|---|
| | a. Four-bar linkage | | |
| | b. Slider-crank mechanism | | |
| | c. Limits of motion and clearances | | |
| 14. | Mining and geology problems | 2 | 3 |
| | a. Strike and dip | | |
| | b. Contours | | |
| | c. Ore vein problems | | |
| | d. Intersections of strata | | |
| | e. Fault planes | | |
| 15. | Topography and mapping | 2 | 3 |
| | a. Plotting contours | | |
| | b. Plotting from survey data | | |
| | c. Map symbols and interpretation | | |
| | TOTALS | 32 | 64 |

Suggested Texts:

(See listing under Basic Drafting I, page .) Also:

Douglass and Hoag, Descriptive Geometry, 1962, Holt, Rinehart & Winston.

Hawk, Theory and Problems of Descriptive Geometry, 1962, Schaum's Outline Series.

Pare, Loving and Hill, Descriptive Geometry, 3rd Ed., 1965, Macmillan.

Warner and McNeary, Applied Descriptive Geometry, 5th Ed., 1959, McGraw-Hill.

Workbooks by the above authors.

## Electrical and Electronic Drafting (2-4) 3

A course emphasizing conventional techniques and methods of representing electrical and electronic systems, with particular attention to modern electro-physical advancements and precision layout of miniature and microminiature circuitry.

| | Topic | Lecture | Laboratory |
|---|---|---|---|
| 1. | Electrical and electronic symbols | 4 | 8 |
| | a. Common symbols | | |
| | (1) connectors and crossovers | | |
| | (2) battery, resistor, capacitor, inductor, ground | | |
| | (3) switches and relays | | |
| | (4) transformers | | |
| | b. Electronic devices | | |
| | (1) diodes and transistors | | |
| | (2) electron tubes | | |
| | c. Logic symbols | | |
| | (1) adders | | |
| | (2) amplifiers | | |
| | (3) gates | | |
| | (4) counters | | |
| | (5) oscillators | | |
| | (6) signal identifiers | | |
| 2. | Block (flow) diagrams | 3 | 7 |
| | a. Layout | | |
| | (1) stages and circuit modules | | |
| | (2) signal paths | | |
| | (3) lettering and symbols | | |
| | b. Logic diagrams | | |
| | (1) logical functions | | |
| | (2) symbols | | |
| | (3) truth tables | | |

Electrical and Electronic Drafting--Continued

c. Analog programming diagrams
d. Digital programming diagrams

3. Schematic diagrams 4 7

a. Layout
    (1) sketching and layout grids
    (2) symbols and part identification
    (3) density and symmetry
b. Tube circuits
    (1) heater connections
    (2) waveform designation
c. Mechanical linkages
    (1) switches and relays
    (2) drive mechanisms
d. Circuit packs
    (1) separation
    (2) interruption and return

4. Pictorial Diagrams and Drawings 2 3

a. Review of pictorial drawings
    (1) isometric
    (2) oblique
    (3) dimetric, trimetric and perspective
b. Use in production drawings
    (1) component representation
    (2) distortion in assembly drawings

5. Printed circuit drawings 4 8

a. Printed circuits
    (1) base construction
    (2) conductor spacing
    (3) through connectors
b. Printed circuit drawings
    (1) placement of components
    (2) master grids
    (3) use of overlays

Electrical and Electronic Drafting--Continued

- (4) adhesive layout aids
- (5) crossovers
- (6) bypass, grid, heater and ground lines
- (7) peel coat materials
- (8) registration and accuracy
- (9) drilling, assembly, and marking drawings

6. Printed circuit production 2 5

    - a. Base materials
        - (1) paper phenolic
        - (2) lucite
        - (3) fiber glass
        - (4) thicknesses
    - b. Foils
        - (1) materials
        - (2) thicknesses
    - c. Conductor layout
        - (1) offset printing
        - (2) photoengraving
        - (3) silk screen
        - (4) etching

7. Integrated and microminiature circuits 4 7

    - a. Construction
        - (1) thin-film circuits
        - (2) diffusion and epitaxial growth processes
        - (3) multiple-step masking
    - b. Drawings
        - (1) master scale layout
        - (2) bar layout
        - (3) bonding diagram
        - (4) intraconnection diagram
        - (5) scale and accuracy
        - (6) exploded assemblies

Electrical and Electronic Drafting--Continued

8. Electrical power diagrams 2 4

    a. Schematic diagrams
        (1) power symbols
        (2) layout
    b. Logic diagrams
        (1) logical symbols
        (2) layout
        (3) relation to schematic diagrams
    c. One-line diagrams
        (1) standard symbols and abbreviations
        (2) location of high voltage lines
        (3) notes n pertinent information
    d. Detail drawings
        (1) standard
        (2) special

9. Power distribution, instrumentation and control 4 6

    a. Motor control
        (1) switches
        (2) circuit-breakers
        (3) contactors
        (4) relays
        (5) two- and three-wire controls
    b. Functions of control
        (1) starting
        (2) protection
        (3) running
        (4) speed regulation
        (5) stopping
    c. Control diagrams
        (1) symbols
        (2) drum controllers
        (3) electronic controllers

Electrical and Electronic Drafting--Continued

| | | | |
|---|---|---|---|
| d. | Application to automated tools | | |
| (1) | part drawings | | |
| (2) | process sheets | | |
| (3) | logic elements | | |
| (4) | block diagrams | | |
| 9. | Mechanical layout of wiring | 2 | 5 |
| a. | Harnesses | | |
| (1) | mechanical assembly | | |
| (2) | outline drawing | | |
| (3) | harness diagram | | |
| (4) | breakout points | | |
| (5) | wire identification | | |
| b. | Routing tables | | |
| 10. | Cabinet, chassis and panel design | 1 | 4 |
| a. | Sheet-metal layouts | | |
| (1) | pattern drawings | | |
| (2) | construction drawings | | |
| b. | Chassis manufacture | | |
| (1) | construction drawings | | |
| (2) | layout and time rate tables | | |
| (3) | hole and terminal data | | |
| c. | Assembly drawings | | |
| (1) | component location | | |
| (2) | wiring requirements | | |
| d. | Photodrawing | | |
| | TOTALS | 32 | 64 |

Electrical and Electronic Drafting--Continued

Suggested Texts:

Baer, Electrical and Electronics Drawing, 2nd Edition, 1966, McGraw-Hill

Raskhodoff, Electronic Drafting and Design, 1966, Prentice-Hall

Shiers, Electronic Drafting, 1962, Prentice-Hall

Shiers, Electronic Drafting Techniques and Exercises, 1963, Prentice-Hall

Additional Recommended References:

Heine, Dunlap and Jones, How to Read Electrical Blueprints, 1970, American Technical Society

Mandl, Directory of Electronic Circuits with a Glossary of Terms, 1966, Prentice-Hall

Special Equipment or Facilities Recommended:

Samples of various electrical and electronic units for study

Elementary printed circuit production kit, either manual or photo etching type (as manufactured by KEPRO, and available from Allied Electronics, Chicago, for example)

## Graphical Analysis (2-4) 3

A course emphasizing graphical methods for data analysis and reduction, including nomography and empirical formula derivation. Graphical methods in the calculus and solution of equations. Of great value to students likely to be involved in experimental laboratory work or reduction of field data.

Note: None of the schools surveyed offered a course resembling the above description; however, a similar course has been taught for several years at Texas A&M University and has been approved for inclusion in the proposed Engineering Technology curriculum at that institution. Former students of the course have indicated that they found the subjects presented to be interesting and useful to them in their work, and in many instances have contributed to their better understanding of concepts not otherwise presented by graphical analogy, particularly mathematical concepts.

| | Topic | Lecture | Laboratory |
|---|---|---|---|
| 1. | Graphical construction principles | 1 | 2 |
| | a. Review of necessary geometric principles | | |
| | (1) coordinate systems | | |
| | (2) point and line location | | |
| | (3) parallels and perpendicular | | |
| | (4) angles | | |
| | (5) tangencies | | |
| | (6) reading scales | | |
| | b. Error analysis | | |
| | (1) errors in data | | |
| | (2) errors in construction | | |
| | (3) absolute *vs.* relative error | | |
| 2. | Graphical data presentation | | |
| | a. General considerations | | |

Graphical Analysis--Continued

(1) coordinate systems
(2) point and line location
(3) parallels and perpendiculars
(4) angles
(5) tangencies
(6) reading scales

b. Error analysis
(1) errors in data
(2) errors in construction
(3) absolute vs. relative error

2. Graphical data presentation 3 6

a. General considerations
(1) neatness and accuracy
(2) item identification
(3) visual integrity

b. Choice of form
(1) qualitative vs. quantitative data
(2) comparative data
(3) mathematical vs. empirical data
(4) continuous vs. discrete data

c. Graph forms
(1) line graphs
(2) bar, pie and other area charts
(3) flow, logic and schematic diagrams
(4) coordinate grids

3. Graphs for three variables 2 4

a. Parallel-line families
(1) on rectilinear coordinates
(2) on semilog coordinates
(3) on logarithmic coordinates

b. Non-parallel-line families
(1) on rectilinear coordinates
(2) on semilog coordinates
(3) on logarithmic coordinates

c. Curvilinear families

d. Three-dimensional (pictorial) graphs

## Graphical Analysis--Continued

4. Functional scales 1 2
    a. Review of functional notation and meaning
    b. The scale equation
        (1) scale modulus
        (2) writing the scale equation
        (3) tabulating the scale equation
    c. Calibrating the scale
        (1) scale divisions and spacing
        (2) using tabulated scale equation
        (3) projection from printed scales
        (4) graphical subdivision of scales

5. Alignment charts-general 1 2
    a. Uses and function
    b. Alignment principles
        (1) three variables
        (2) three scales
        (3) the isopleth
        (4) preferred location of "unknown" scale
    c. Relationship to network charts
        (1) principle of duality
        (2) conversion from network to alignment chart

6. Parallel-scale alignment charts 2 4
    a. General form
        (1) scale arrangement
        (2) euqation form
    b. The outer scales
        (1) location
        (2) calibration
    c. The middle scale
        (1) location--mathematical method
        (2) location--semi-graphical method
        (3) calibration--mathematical method
        (4) calibration--semi-graphical method

Graphical Analysis--Continued

- d. Labelling
  - (1) title
  - (2) equation
  - (3) scales
  - (4) key and legend

7. N or Z charts 2 4

- a. General form
  - (1) scale arrangement
  - (2) equation form
- b. The outer scales
  - (1) location
  - (2) calibration
- c. The diagonal scale
  - (1) location--graphical method
  - (2) location--semigraphical method for zeros inaccessible
  - (3) calibration--mathematical method
  - (4) calibration--semi-graphical method

8. Combination charts 2 4

- a. General principles
  - (1) more than three variables
  - (2) superposition principle
  - (3) number of scales
- b. Parallel and parallel types
  - (1) scale arrangement
  - (2) equation form
  - (3) "dummy" variables and "turning" scales
- c. Proportion types
  - (1) "N + Z" arrangement
  - (2) equation form
  - (3) turning scale

9. Graphical anamorphosis 1 2

- a. General principles

Graphical Analysis--Continued

(1) linear network from curvilinear network
(2) alignment chart from linear network
b. Graphical constructions
(1) arbitrary coordinate selection
(2) arbitrary curve-pair selection
(3) "staircase" construction
(4) bilineality check for entire curve family
(5) transfer from linear network to alignment chart

10. Empirical data analysis 5 10

a. General principles
(1) plot data
(2) examine plot
(3) "fit" equation to data
b. Two-variable correlation
(1) linear form Y=MX + B; X and Y linear
(2) quasi-linear forms; X or Y non-linear
(3) polynomial approximation--semi graphical method
(4) harmonic analysis--semi-graphical, or vector, method.
c. Three-variable correlation
(1) parallel forms
(2) convergent/divergent linear forms
(3) non-linear forms

11. Solution of equations 2 4

a. Linear systems
(1) by orthographic projection
(2) by graphical reduction
b. Roots of polynomials
(1) number and sign of real roots
(2) complex roots
(3) successive graphical approximation

Graphical Analysis--Continued

12. Mathematical constructions 1 2

    a. Multiplication and division of arbitrary functions
        (1) reciprocal of a function
        (2) square or square root of a function
    b. Graphical elimination of parameter, t, from $x = f(t)$ and $y = g(t)$
        (1) plots of $f(t)$ and $g(t)$
        (2) form $y = F(x)$ by projection

13. Graphical calculus 4 8

    a. Integration
        (1) area "under" the curve
        (2) area (integral) of a rectangle
        (3) area (integral) of a trapezoid
        (4) pole-ray diagram
        (5) determination of pole point
        (6) determination of scales
    b. Differentiation
        (1) analogy to integration
        (2) slope/tangent principle
        (3) pole point and scales
    c. Applications
        (1) areas, work and power
        (2) centroids
        (3) rates, velocity and acceleration

14. Special projects 5 10

Students should be encouraged to pursue graphical analysis of problems from their own specialties. For example experimental data could be taken and plotted, then empirical relationships could be derived (or verified, if already known.) Alignment charts for the relationships might be constructed, and if applicable, rates of change, etc., could be determined for the data by graphical calculus.

TOTAL $\overline{32}$ $\overline{64}$

Graphical Analysis--Continued

Suggested Texts:

Note: No single text contains all of the material outlined above, but the following books, taken collectively, cover the subject adequately:

Adams, Nomography, 1964, Archon Books

Davis, Nomography and Empirical Equations, 1962, Reinhold

Douglass and Adams, Elements of Nomography, 1947, McGraw-Hill

Rule and Coons, Graphics, 1961, McGraw-Hill

Woodworth, Graphical Simulation, 1964, International Textbook Co.

Additional Recommended References:

Adams, An Index of Nomograms, 1950, Wiley

Lipka, Graphical and Mechanical Computation, 1918, Wiley

Willers, (trans. Robert T. Beyer) Practical Analysis: The Graphical and Numerical Methods, 1948, Dover Publications

Special Equipment or Facilities Recommended:

Planimeter (polar type) for demonstration of mechanical integration

## Foundry Drafting (2-4) 3

Drafting practices applied to foundry production methods. Basics of pattern making, casting and related shop processes. Preparation of detail drawings for specifications required by those processes, with emphasis on dimensional requirements. Designed for students to enter industries relying heavily on foundry production.

Note: No course resembling the above description was offered by any of the schools surveyed; however, eight of the industries surveyed employed draftsmen classified as Foundry Draftsman. The following outline is based upon their responses, with lecture:laboratory ratios maintained at approximately 2:4 when possible, commensurate with overall course structure.

| Topic | Lecture | Laboratory |
|---|---|---|
| 1. Forming processes | 2 | 4 |
| a. Casting | | |
| (1) die casting | | |
| (2) sand casting | | |
| (3) shell castings | | |
| (4) centrifugal casting | | |
| (5) investment casting | | |
| b. Forging | | |
| c. Welding | | |
| (1) processes | | |
| (2) representation | | |
| c. Shrinkage | | |
| (1) shrinkage of various metals | | |
| (2) allowances for shrinkage in drawings | | |
| 2. Pattern making | 2 | 5 |
| a. Pattern materials and design | | |
| (1) basic patterns | | |
| (2) draft allowance | | |

Foundry Drafting--Continued

(3) parting lines and pattern removal
(4) cores and core boxes
b. Pattern drawings
(1) basic patterns
(2) core patterns
(3) shrinkage allowance
(4) draft allowance
(5) pattern and core assemblies

3. Machining practices applied to castings and forgings 2 5

a. Drilling and boring
b. Facing and turning
c. Planning and shaping
d. Surface finishes
e. Specification of operations on drawings

4. Foundry and forge operations 2 5

a. Foundry operations
(1) melting
(2) pouring
(3) cleaning castings
(4) sand mixing
b. Forging operations
(1) heating
(2) hammers
(3) presses
(4) upsetters
c. Inspection of parts
d. Preparation for machining

5. Detail drawings 4 5

a. Pattern drawings
(1) drawing of finished part
(2) drawing for pattern
(3) shrinkage and draft allowance
(4) fillets and rounds

Foundry Drafting--Continued

- (5) provisions for pattern construction
- (6) core drawings
- (7) core-box drawings
- (8) match-plate drawings

- b. Casting drawings
  - (1) as-cast drawings
  - (2) machining drawings
- c. Forging drawings
  - (1) as-forged drawings
  - (2) machining drawings
- d. Use of overlay drawings
- e. Dimensional units and tolerances

6. Dimensioning practices 4 5

- a. Review of general practices
  - (1) selection and placement
  - (2) notes
  - (3) tolerances and limits
- b. Practices peculiar to pattern, foundry and forging work
  - (1) pattern dimensions and tolerances
  - (2) casting dimensions and tolerances
  - (3) forging dimensions and tolerances
  - (4) machining dimensions and notes

7. Thread and fastener representation 2 4

- a. Standard thread forms
  - (1) machined
  - (2) cast and forged
- b. Fasteners
  - (1) bolts and nuts
  - (2) rivets
  - (3) pins and keys

Foundry Drafting--Continued

| | | |
|---|---|---|
| 8. Assembly drawings | 2 | 5 |
| a. Assemblies of cast parts | | |
| (1) multiview | | |
| (2) sections | | |
| b. Exploded assemblies | | |
| 9. Strength of cast and forged materials | 2 | 4 |
| a. Properties | | |
| (1) elasticity | | |
| (2) britleness | | |
| (3) hardness | | |
| (4) machinability | | |
| b. Treatment | | |
| (1) hardening | | |
| (2) tempering | | |
| (3) annealing | | |
| 10. Gears, pulleys and drivers | 2 | 4 |
| a. Production requirements | | |
| (1) cast | | |
| (2) forged | | |
| b. Representation | | |
| (1) gear blanks | | |
| (2) design for strength and economy | | |
| 11. Freehand drawing | 2 | 3 |
| a. Review techniques | | |
| b. Design sketches | | |
| (1) for castings | | |
| (2) for forgings | | |
| (3) for patterns | | |
| 12. Simplified drafting practices | 2 | 5 |
| a. Repetitive details | | |

### Foundry Drafting--Continued

| | | | |
|---|---|---|---|
| | (1) use of phantom lines | | |
| | (2) treatment of hole patterns | | |
| | b. Detail representation | | |
| | (1) use of word descriptions | | |
| | (2) use of symbolic representation | | |
| | (3) omission of hidden lines | | |
| | (4) use of partial and half views | | |
| | c. Labor saving devices | | |
| | (1) mechanical or typed lettering | | |
| | (2) adhesive and transfer symbols | | |
| | (3) templates | | |
| 13. | Pictorial drawing | 1 | 1 |
| | a. Types | | |
| | (1) axonometric | | |
| | (2) oblique | | |
| | (3) perspective | | |
| | b. Treatment of fillets and rounds | | |
| 14. | Intersections | 1 | 3 |
| | a. Review methods | | |
| | (1) plane | | |
| | (2) curved surfaces | | |
| | b. Applications to case or forged machine elements | | |
| 15. | Charts and graphs | 1 | 3 |
| | a. Media | | |
| | (1) Mylar | | |
| | (2) scribe-coat | | |
| | (3) coated metal | | |
| | b. Accuracy requirements | | |
| | (1) dimensional accuracy | | |
| | (2) standard line widths | | |
| | TOTALS | 32 | 64 |

Foundry Drafting--Continued

Suggested Texts:

(See general drawing texts listed under Basic Drafting I.) Also:

Hanel, Text in Pattermaking, 1949, Bruce Publishing Co.

Ludwig, Metalwork Technology and Practice, 1955, McKnight

Smith, Forging and Welding, 1956, McKnight

Additional Recommended References:

Tolerances for Impression Die Forgings, 1963, Drop Forging Association.

Special Equipment or Facilities Recommended:

Opportunity to visit pattern, foundry and forging installations would be beneficial.

## Machine Drafting (2-4) 3

A continuation of Basic Drafting, with additional emphasis on industrial applications of drafting. Methods of representing more complex and specialized areas of application, with consideration given to specifications for controlled precision production of mechanical systems.

| | Topic* | Lecture | Laboratory |
|---|---|---|---|
| 1. | Successive auxiliary views | 1 | 2 |
| | a. Review fundamental concepts | | |
| | b. Use in pictorials | | |
| 2. | Threads and fasteners | 2 | 4 |
| | a. Review symbols and notes | | |
| | b. Special fasteners | | |
| | (1) locknuts | | |
| | (2) pins and keys | | |
| | (3) rivets | | |
| | (4) set and machine screens | | |
| | (5) head types | | |
| 3. | Welding Drawings | 2 | 2 |
| | a. Welding process | | |
| | (1) oxy-acetylene | | |
| | (2) arc | | |
| | (3) inert gas | | |
| | (4) induction | | |
| | (5) flash | | |
| | (6) forge | | |
| | b. Types of welds | | |
| | (1) fillet | | |
| | (2) plug or slot | | |
| | (3) groove | | |

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*See footnote, page .

Machine Drafting--Continued

| Topic | Lecture | Laboratory |
|---|---|---|
| c. Types of joints | | |
| (1) butt | | |
| (2) corner | | |
| (3) tee | | |
| (4) lap | | |
| (5) edge | | |
| d. Welding symbols | | |
| (1) fillet, plug and groove | | |
| (2) spot and seam | | |
| (3) flash | | |
| 4. Shop processes | 2 | 4 |
| a. Forging | | |
| (1) drop | | |
| (2) press | | |
| (3) rolling | | |
| (4) upsetting | | |
| (5) extruding | | |
| b. Casting | | |
| (1) methods | | |
| (2) design | | |
| c. Machining | | |
| (1) methods | | |
| (2) finishes | | |
| d. Plating and coating | | |
| 5. Detail drawings | 3 | 6 |
| a. Layout and arrangement | | |
| b. Types | | |
| (1) pattern shop | | |
| (2) forging | | |
| (3) machine | | |
| (4) welding | | |
| (5) stamping | | |

## Machine Drafting--Continued

| Topic | Lecture | Laboratory |
|---|---|---|
| 6. Assembly drawings | 2 | 6 |
| a. General assemblies | | |
| (1) views | | |
| (2) dimensions | | |
| (3) hidden lines | | |
| (4) parts identification | | |
| b. Detail assemblies | | |
| c. Diagram assemblies | | |
| d. Assembly sectioning | | |
| e. Installation assemblies | | |
| f. Working-drawing assemblies | | |
| g. Check assemblies | | |
| 7. Exploded pictorials | 1 | 4 |
| a. Alignment of parts | | |
| b. Axonometric | | |
| c. Oblique | | |
| d. Perspective | | |
| e. Sections | | |
| 8. Drafting room practices | 2 | 3 |
| a. Department organization | | |
| b. Duties and responsibilities of draftsmen | | |
| c. Documentation of drawings | | |
| d. Storage, retrieval and reproduction of drawings | | |
| 9. Drawing reproduction | 2 | 3 |
| a. Ferro process | | |
| b. Diaza process | | |
| c. Silver process | | |
| d. Electrostatic process | | |
| e. Heat process | | |

## Machine Drafting--Continued

| Topic | Lecture | Laboratory |
|---|---|---|
| f. Microfilming | | |
| g. Computerization | | |
| 10. Gears, pulleys and drives | 2 | 3 |
| a. Types of gears | | |
| (1) spur | | |
| (2) rack | | |
| (3) internal | | |
| (4) pinion | | |
| (5) bevel | | |
| (6) miter | | |
| (7) helical | | |
| (8) worm | | |
| (9) chain sprockets | | |
| b. Spur gear terms | | |
| c. Tooth profiles | | |
| d. Detailing gears | | |
| e. Rack and pinion | | |
| f. Bevel and miter gears | | |
| g. Formulas and tables | | |
| h. Splines and serrations | | |
| i. Pulleys and belts | | |
| (1) flat | | |
| (2) vee | | |
| j. Bearings | | |
| (1) types | | |
| (2) selection | | |
| (3) drawing representation | | |
| 11. Cams | 2 | 2 |
| a. Types | | |
| (1) plate | | |
| (2) disc | | |
| (3) cylindrical | | |
| (4) face | | |

Machine Drafting--Continued

| | Topic | Lecture | Laboratory |
|---|---|---|---|
| | b. Cam motions | | |
| | (1) uniform | | |
| | (2) uniformly accelerated | | |
| | (3) harmonic | | |
| | (4) others | | |
| | c. Followers | | |
| | (1) flat faced | | |
| | (2) roller | | |
| | (3) radial and offset | | |
| | (4) rotating | | |
| | d. Motion diagrams | | |
| | e. Formulas and tables | | |
| 12. | Properties of materials | 1 | 2 |
| | a. Metals | | |
| | (1) sources | | |
| | (2) processes | | |
| | (3) applications | | |
| | b. Plastics | | |
| | c. Woods | | |
| | d. Miscellaneous | | |
| 13. | Simplified drafting | 2 | 3 |
| | a. Purpose and applications | | |
| | b. Symbols | | |
| | c. Repeated details | | |
| | d. Tabular dimensioning | | |
| 14. | Axonometric pictorials | 1 | 3 |
| | a. Isometric | | |
| | b. Dimetric | | |
| | c. Trimetric | | |
| | d. Eckhardt's method | | |

## Machine Drafting--Continued

| Topic | Lecture | Laboratory |
|---|---|---|
| 15. Perspective drawing | 0 | 2 |
| a. Perspective grids | | |
| b. Use in assemblies and technical manuals | | |
| 16. Charts and graphs | | |
| a. Application to technical data | | |
| b. Multiple-line graphs | | |
| c. Logarithmic and semi-logarithmic grids | | |
| d. Schematics and process diagrams | | |
| 17. Precision dimensioning | 2 | 6 |
| a. Special dimensions | | |
| (1) mating dimensions | | |
| (2) machine, pattern and forging dimensions | | |
| (3) notes | | |
| b. Preference in dimensioning | | |
| (1) functional dimensions | | |
| (2) shop processes | | |
| c. Classes of fit | | |
| (1) running and sliding fits | | |
| (2) location fits | | |
| (3) force fits | | |
| (4) tolerances and limits | | |
| (5) standard tables | | |
| d. Surface quality | | |
| (1) roughness | | |
| (2) waviness | | |
| (3) lay | | |
| e. Machine finishes | | |
| (1) ream | | |
| (2) grind | | |
| (3) hone | | |

Machine Drafting--Continued

| | Topic | Lecture | Laboratory |
|---|---|---|---|
| | (4) lap, polish | | |
| 18. | Military standards | 2 | 2 |
| | a. MIL-STD 100, General drafting practices | | |
| | b. MIL-STD 8C, Dimensioning practices | | |
| | c. MIL-STD 12, Abbreviations | | |
| | d. MIL-STD 16, Electrical-electronic symbols | | |
| | e. MIL-STD 17, Mechanical symbols | | |
| | f. MIL-STD 18, Structural symbols | | |
| | g. MIL-STD 23, Nondestructive symbols | | |
| 19. | Freehand drawing | 1 | 3 |
| | a. Review of techniques | | |
| | b. Design sketches | | |
| | c. Layout sketches | | |
| | d. Pictorial sketches | | |
| 20. | Intersection and Development | 1 | 2 |
| | a. Intersections | | |
| | (1) plane | | |
| | (2) singly-curved surfaces | | |
| | (3) doubly-curved surfaces | | |
| | (4) contour lines | | |
| | b. Developments | | |
| | (1) plane and singly-curved surfaces | | |
| | (2) doubly-curved surfaces | | |
| | c. Transition pieces | | |
| | d. Marine and aerodynamic applications | | |
| | TOTALS | 32 | 64 |

## Machine Drafting--Continued

Suggested Texts:

(See listing under Basic Drafting , page ).

Additional Recommended References:

Department of Defense, MIL-STD 100, 8C, 12, 16, 17, 18, 23.

Special Equipment or Facilities:

(See listing under Basic Drafting , page ).

Availability of a school machine shop or local industry would be desirable for inspection tours.

## Machine and Tool Drafting (2-4) 3

Intended for students who wish to specialize in mechanical design drafting. Emphasis on design and analysis of basic drive mechanisms, including gears, cams and linkages. Jig and fixture design for quantity production. Production quality control and numerically-controlled tools. Individual and group projects.

| Topic | Lecture | Laboratory |
|---|---|---|
| 1. Statics | 3 | 4 |
| a. Force systems | | |
| b. Resultants and equilibrants | | |
| c. Reactions | | |
| (1) tension and compression | | |
| (2) shear | | |
| (3) bending moments | | |
| d. Graphical analysis | | |
| (1) free body diagrams | | |
| (2) vector polygons | | |
| (3) Bow's notation | | |
| e. First and second moments | | |
| f. Static determinancy | | |
| 2. Strength of materials | 3 | 5 |
| a. Tensile and compressive strength | | |
| b. Stress and strain | | |
| c. Poisson's ratio | | |
| d. Modulus of elasticity | | |
| e. Load, shear, moment and deflection diagrams | | |
| f. Hardness | | |
| (1) Brinell | | |
| (2) Rockwell | | |

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## Machine and Tool Drafting--Continued

    - (3) Vickers
    - (4) Shore

3. Linkages 2 4

  a. Plane motion
    - (1) translation
    - (2) rotation

  b. Kinematic chains
    - (1) relative motion
    - (2) translating pairs
    - (3) rotating pairs

  c. Relative motion
    - (1) instantaneous centers
    - (2) relative velocities

  d. Straight-line mechanisms

  e. Graphical methods

4. Cams 2 4

  a. motion
    - (1) reciprocating
    - (2) rotating
    - (3) forces in cams
    - (4) displacement, velocity, acceleration and jerk

  b. Types of curves
    - (1) plate
    - (2) disk
    - (3) cylindrical
    - (4) inverse
    - (5) conical

  c. Types of followers
    - (1) reciprocating
    - (2) rocker-arm
    - (3) offset
    - (4) knife-edge
    - (5) roller

Machine and Tool Drafting--Continued

  d. cam design
    (1) types of motion
    (2) displacement diagrams
    (3) plotting cam profiles

5. Design process 3 6

  a. Problem identification
    (1) requirements
    (2) specifications
  b. Preliminary design
    (1) brainstorming
    (2) design sketches
  c. Design refinement
    (1) advantages and disadvantages
    (2) check against specifications
  d. Design analysis
    (1) function
    (2) strength
    (3) materials
    (4) appearance
    (5) cost
  e. Selection of design
  f. Design implementation
    (1) working drawings
    (2) model
    (3) descriptive report

6. Jigs and fixtures 1 4

  a. Jigs
    (1) function and operation
    (2) drilling jigs
  b. Fixtures
    (1) function and operation
    (2) holding fixtures
  c. Manufacturing tooling applications
  d. Assembly tooling applications

Machine and Tool Drafting--Continued

7. Individual projects 2 5
    a. Machine elements
        (1) linkages
        (2) cams
    b. Jigs and fixtures

8. Group projects 1 1
    a. design team organization
    b. team dynamics
    c. incorporation into design process

9. Model building 0 2
    a. Model types
        (1) prototype
        (2) mock-up
        (3) scale models
        (4) preliminary
    b. Model construction
        (1) scale selection
        (2) materials
        (3) fabrication methods

10. Gears and drive trains 3 7
    a. Gear nomenclature
        (1) types
        (2) tooth profiles
        (3) representation
    b. Gear formulas and tables
    c. Gear trains
        (1) rack and pinion
        (2) spur
        (3) bevel
        (4) worm
        (5) planetary
    d. Chain drives
        (1) chains
        (2) sprockets
        (3) chain tension

Machine and Tool Drafting--Continued

e. Belt drives
  (1) flat
  (2) vee
  (3) multiple
  (4) belt tension
  (5) belt friction
f. Coordination with cam mechanisms

11. Shop processes 3 6

a. Forging
  (1) drop
  (2) press
  (3) rolling
  (4)
  (5) extruding
  (6) drawings
b. Casting
  (1) sand casting
  (2) die casting
  (3) patterns
  (4) materials
  (5) shrinkage
  (6) casting design
c. Machining
  (1) drilling and boring
  (2) turning and facing
  (3) Shaping and planing
  (4) Grinding and honing and polishing
d. Plating and coating
  (1) electroplating
  (2) dipping
  (3) metallic vapor coating
e. Hardening and heat treating
  (1) quenching
  (2) case hardening
  (3) annealing
  (4) cold working

### Machine and Tool Drafting--Continued

| | | |
|---|---|---|
| 12. Guest speakers | 1 | 0 |
| a. Tool designer | | |
| b. Design engineer | | |
| c. Shop foreman | | |
| d. Master machinist | | |
| 13. Field trips | 1 | 1 |
| a. Industrial design department | | |
| b. Tool and die manufacturer | | |
| c. Machine shop | | |
| 14. Systems analysis | 2 | 4 |
| a. Task delineation | | |
| b. Sequence determination | | |
| c. Activities networks | | |
| d. PERT | | |
| e. Critical path scheduling | | |
| 15. Production control | 1 | 5 |
| a. Product sampling | | |
| b. Testing procedures | | |
| (1) gauges | | |
| (2) sonic and X-ray techniques | | |
| (3) optical techniques | | |
| (4) destructive testing | | |
| c. Inventory control | | |
| 16. Numerically controlled tools | 1 | 4 |
| a. Automatic machine tools | | |
| b. Tool path control | | |
| (1) tracer and director control | | |
| (2) magnetic and paper tape control | | |
| c. Feeding, holding, indexing and ejection | | |

Machine and Tool Drafting--Continued

- d. Numerical control languages
  - (1) APT
  - (2) others

17. Computer graphics 3 2

- a. Terminology and equipment
  - (1) scanners and plotters
  - (2) CRT output
- b. Digital and analog systems
- c. Programming languages
- d. Mathematical modeling
- e. Applications
  - (1) numerical control
  - (2) design and analysis

TOTALS 32 64

Suggested Texts:

Cole, Tool Design, 1970, American Technical Society

Creamer, Machine Design, 1968, Addison-Wesley

Pare, Kimbrell and Francis, Introduction to Engineering Design, 1963 Holt, Rinehart and Winston

Winston, Machine Design, 1970, American Technical Society

Additional Recommended References:

Boddy, Engineering Design Computational Manual, 1969, Holt, Rinehart and Winston

Faires, Design of Machine Elements, 3rd Edition, 1955, Macmillan

## Machine and Tool Drafting--Continued

Additional Recommended References--Continued:

Gibson, Introduction to Engineering Design, 1968, Holt Rinehart and Winston

Winston, Machine Design, 1970, American Technical Society

Wilson and Michels, Mechanism--Design-Oriented Kinematics, 1970, American Technical Society

## Map & Topographic Drafting (2-4) 3

Designed to prepare the draftsman to specialize in map construction. Use of survey field data. Topographic mapping. Types of global projections; conformal, equal area and others. Use of special mapping instruments. Non-geographical mapping. Photogrammetry and stereo mapping.

| | Topic | Lecture | Laboratory |
|---|---|---|---|
| 1. | Types of maps | 4 | 5 |

- a. Geographic
- b. Cadastral
- c. Topographic
- d. Photomaps
  - (1) aerial photos
  - (2) mosaics
- e. Classes of maps
  - (1) Class I--from original data
  - (2) Class II--from Class I
  - (3) Class III--statistical

| | Topic | Lecture | Laboratory |
|---|---|---|---|
| 2. | Classification of map information | 2 | 5 |

- a. Culture (man-made)
  - (1) highways
  - (2) railroads
  - (3) towns and cities
  - (4) fences
  - (5) buildings
  - (6) political or legal boundaries
- b. Relief
  - (1) valleys
  - (2) hills
  - (3) plains
  - (4) plateaus
  - (5) mountains

Map & Topographic Drafting--Continued

- c. Hydrography
    - (1) oceans
    - (2) seas
    - (3) lakes
    - (4) ponds
    - (5) rivers
    - (6) creeks
- d. Vegetation
    - (1) forests
    - (2) orchards
    - (3) meadows
    - (4) crops
    - (5) desert
    - (6) swamps and marshes

3. Special mapping instruments 2 4

- a. Drawing instruments
    - (1) contour pen
    - (2) railroad pen
    - (3) highway curves
- b. Scaling and measuring instruments
    - (1) proportional dividers
    - (2) pantograph
    - (3) planimeter
- c. Lettering devices
    - (1) templates
    - (2) pens
- d. Media
    - (1) tracing paper, cloth and film
    - (2) cross-section paper
    - (3) photographic media
    - (4) scribe and peel coat film

4. Lettering for maps 2 5

- a. Freehand lettering
- b. Mechanical hand lettering
    - (1) Leroy
    - (2) Wrico

Map & Topographic Drafting--Continued

- c. Adhesive and printed lettering
    - (1) Prestype, Artype and Para-Tipe
    - (2) Veritype
    - (3) Photo-lettering (Photo-Typositor)
- d. Types of lettering
    - (1) civil and political divisions
    - (2) hydrographic
    - (3) public works
    - (4) titles
    - (5) legends and notes
    - (6) marginal information
    - (7) north points and compass

5. Traverses and surveys 3 7
    - a. Traverses
        - (1) azimuths
        - (2) grids
        - (3) closure
        - (4) orders of traverses
    - b. Surveys
        - (1) geodetic surveys
        - (2) triangulation
        - (3) markers
        - (4) survey instruments
    - c. Leveling
        - (1) orders of precision
        - (2) networks
        - (3) bench marks
        - (4) instruments

6. Map symbols 4 8
    - a. Cultural symbols
        - (1) boundaries, fences and walls
        - (2) buildings, towns and cities
        - (3) public works and structures
        - (4) highways and railroads
        - (5) military symbols

Map & Topographic Drafting--Continued

- b. Relief symbols
  - (1) contour lines
  - (2) relief shading
- c. Hydrographic symbols
  - (1) closed bodies of water
  - (2) dry lakes and flats
  - (3) flowing bodies of water
  - (4) glaciers
  - (5) depth curves
  - (6) navigation aids
  - (7) nautical chart symbols
- d. Vegetation
  - (1) tree symbols-natural
  - (2) tree symbols-cultivated (orchards)
  - (3) cultivated crops
- e. Natural resources
  - (1) quarries and mineral deposits
  - (2) oil and gas deposits
  - (3) geological symbols
- f. Miscellaneous
  - (1) U.S. Forest Service symbols
  - (2) air navigation symbols
  - (3) golf courses
  - (4) underground structures
  - (5) signboards and highway markers

| | | |
|---|---|---|
| 7. Contours and profiles | 4 | 8 |

- a. Contours
  - (1) interpretation
  - (2) intervals
  - (3) spot elevations
  - (4) plotting from control points
  - (5) modification for man-made structures
- b. Profiles
  - (1) plotting from contour map
  - (2) plotting contours from prfiles
- c. Interpolation
- d. Line-of-sight visibility problems

- e. Applications
  - (1) drainage and flood control
  - (2) road, dam and site location

8. Map projections 3 6

- a. Cylindrical
  - (1) Mercator
  - (2) universal transverse Mercator
- b. Conic
  - (1) polyconic
  - (2) Albers
  - (3) Lambert conic
- c. Azimuthal
  - (1) gnomonic
  - (2) stereographic
  - (3) orthographic
  - (4) equidistant
  - (5) Lambert equal-area
- d. Characteristics
  - (1) equal-area
  - (2) conformal/non-conformal
- e. Special projections
  - (1) homolographic (Molleweide)
  - (2) sinusoidal
  - (3) homolasine
  - (4) Van der Grinten
  - (5) interrupted gore
  - (6) interrupted sinusoidal
  - (7) interrupted homolographic
  - (8) interrupted homolosine
  - (9) Boune

9. Map revisions 2 3

- a. Opaquing
- b. Splicing
- c. Engraving

## Map & Topographic Drafting--Continued

|  |  |  |
|---|---|---|
| 10. Photogrammetry | 2 | 3 |

- a. Photography
  - (1) cameras used
  - (2) aircraft
  - (3) flight patterns
  - (4) vertical, oblique and composite photos
- b. Interpretation
  - (1) tones and colors
  - (2) light, shade and shadow
  - (3) relief features
- c. Stereophotography
  - (1) basic principles
  - (2) camera and film
  - (3) viewing stereo pairs
- d. Aerial mosaics
  - (1) controlled
  - (2) uncontrolled

|  |  |  |
|---|---|---|
| 11. Color separation | 1 | 1 |

- a. Overlays
- b. Negatives
  - (1) photographic
  - (2) scribe coat
- c. Photomechanical
  - (1) deep etch
  - (2) photographing
  - (3) negative processing
  - (4) plate preparation
  - (5) press work

|  |  |  |
|---|---|---|
| 12. Working from field notes | 3 | 7 |

- a. Form of field notes
  - (1) tabular data
  - (2) station numbers
  - (3) line or object identification

Map & Topographic Drafting--Continued

- (4) azimuth angles
- (5) elevation angles
- (6) coordinates
- (7) northing and easting
- (8) distances
- (9) field sketches
- (10) time and temperature

b. Plotting from field notes
- (1) correlation with existing maps
- (2) accuracy
- (3) elevation determination
- (4) grid and coordinate systems
- (5) closures, corrections and checks

| | | |
|---|---|---|
| 13. Earthwork calculations | 0 | 2 |

a. Cut and fill limits
- (1) level sites and roads
- (2) angles of repose
- (3) graded sites and roads
- (4) curved roads

b. Cross sections
- (1) plotting from cut and fill
- (2) number and spacing
- (3) station

c. Volumetric calculations
- (1) slicing method
- (2) graphical area calculation
- (3) use of planimeter

| | | |
|---|---|---|
| TOTALS | 32 | 64 |

Map & Topographic Drafting--Continued

Suggested Texts:

Elmer, Map and Topographic, 1959, Engineering Extension Service, Texas A&M University

Sloane and Montz, Elements of Topographic Drawing, 1943, McGraw-Hill

Additional Recommended References:

Brown, Manual of Classroom Instruction in Aerial Photo Interpretation; Short Course of Study, 1952, Dixie Bookbinding

Seelye, Data Book for Civil Engineers, Vol I, Design, 1960, Wiley

Whitmore, Advanced Surveying and Mapping, 1949, International Textbook

Special Equipment or Facilities Recommended:

World globe--at least 12" diameter

Map drawing devices:

- railroad pen
- contour pen
- proportional dividers
- pantograph
- planimeter

Samples of prepared lettering and map symbols

Samples of commercially-prepared maps, including photo and stereo-pair maps

Stereo map viewer

## Numerical Control Graphics (2-4) 3

An introductory course intended to demonstrate existing and potential uses of graphical input/output with high-speed digital computers. Applications to automatic control of production tools. Capabilities of both on-line and off-line printers, plotters and cathode-ray tube display devices. Use of standard coding languages, such as FØRTRAN and APT. Graphical modes of man-machine communication.

Note: None of the schools surveyed offered a course resembling the above description; however, eleven of the industrial firms surveyed responded to questionnaire items concerning Computer Draftsman job requirements. The following suggested outline represents a composite of those item responses and material contained in two texts: William A. Fetter, Computer Graphics in Communication, New York: McGraw-Hill, 1965, and Tobert B. Thornhill, Engieering Graphics and Numerical Control, New York; McGraw-Hill, 1967. Because the development of computer use in graphics and numerical control is relatively new, it is difficult to state with any certainty just how much emphasis should be placed on any of the topics listed below. It is suggested that the topics be given tentatively equal weight in the hope that their study by students and teachers alike will reveal areas which require more or less investigation. It is anticipated that the technician who works with computer graphics and numerical control will evolve into a sort of computer programmer-draftsman combination, and that he will be more concerned with adapting traditional engineering drawings to computer processing and numerically-controlled production than with producing original working drawings. For this reason, a background in technical drafting skills are assumed in the outline, with emphasis placed upon adapting those skills and knowledges to computer processing of graphical information and subsequent applications to design and production technology.

Numerical Control Graphics--Continued

| Topic | Lecture | Laboratory |
|---|---|---|
| 1. Numerical control principles | 5 | 10 |
| a. Basic systems | | |
| (1) the control unit | | |
| (2) open-loop systems | | |
| (3) closed-loop systems | | |
| (4) feedback | | |
| b. Types of numerical control | | |
| (1) cartesian coordinates | | |
| (2) discrete (point-to-point) positioning | | |
| (3) continuous path positioning | | |
| (4) multiaxis control | | |
| 2. Graphical tooling considerations | 5 | 10 |
| a. Dimensioning | | |
| (1) base-line | | |
| (2) incremental | | |
| b. Tool path generation | | |
| (1) straight cuts | | |
| (2) curve cutting | | |
| (3) tolerances | | |
| (4) tool inertia | | |
| c. Cutting tools | | |
| (1) tool radius | | |
| (2) tool path/part surface relation | | |
| (3) inside corners of part | | |
| d. Tool positioning | | |
| (1) point location | | |
| (2) plunge and lift | | |
| (3) spindle rotation | | |
| (4) coolant on/off | | |
| 3. Elementary (numerical) part programming | 5 | 10 |
| a. Point location | | |
| (1) origin selection | | |
| (2) key points | | |

## Numerical Control Graphics--Continued

(3) coordinate determination
(4) sequence path
b. Numerical control (N/C) process sheets
(1) coordinate specification
(2) tool and coolant specifications
(3) remarks column

4. Symbolic programming 6 12

a. Geometric definitions
(1) point
(2) line
(3) circle
(4) tangent
(5) perpendicular
(6) parallel
b. Elements of APT III
(1) geometric element names
(2) motion names
(3) tool specifications
c. Programming a part from part drawing
(1) selection of set point
(2) defining geometric elements
(3) writing the program
d. Repetitive operations
(1) loops
(2) macros

5. Computer-aided design 6 12

a. Scope (design functions)
(1) design logic (decision-making)
(2) computations
(3) design checking
(4) paperwork generation
b. Instantaneous displays
(1) Price's "Design Machine"
(2) M.I.T. "Sketchpad"
(3) General Motors "DAC-1"

Numerical Control Graphics--Continued

- c. Drafting and plotting devices
  - (1) flat-bed plotter
  - (2) drum plotters
  - (3) photo-mechanical and photo-electrical devices

| | | |
|---|---|---|
| 6. Design applications | 5 | 10 |

- a. Configuration drawings
  - (1) orthographic views
  - (2) pictorial views
  - (3) rotation of pictorials
  - (4) view modification
  - (5) stereographic views
- b. Topological analysis
  - (1) three-variable graphs
  - (2) contour maps
  - (3) terrain masking (visibility) analysis
- c. Simulation studies
  - (1) pilot training
  - (2) missile maneuvers
  - (3) tooling verification
  - (4) highway construction

| | | |
|---|---|---|
| TOTALS | 32 | 64 |

Suggested Texts:

Fetter, Computer Graphics in Communication, 1965, McGraw-Hill

Thornhill, Engineering Graphics and Numerical Control, McGraw-Hill

Additional Recommended References:

National Aerospace Standard 938, Aerospace Industries Association of America, Inc.

Numerical Control Graphics--Continued

Additional Recommended References--Continued:

III Research Institute, APT Training Manual for Engineers, 1964, Clearinghouse for Federal Scientific and Technical Information, U.S. Department of Commerce, Springfield, Virginia.

Publications of the Association for Computing Machinery: Computing Reviews, and Communications of the ACM. Departmental subscriptions are suggested and encouraged.

California Computer Products, Inc. Calcomp Newsletter (formerly Digital Plotting Newsletter), Anaheim, California (free subscription upon request.)

Special Facilities or Equipment Recommended:

Opportunity to visit a manufacturer using N/C would be beneficial; also observation or even limited use of a numerically-controlled plotter or other graphical output device would be desirable. Accessibility to such equipment have significant bearing on the structure of the course and problems assigned.

A 16 mm color sound film on DAC-1 is available on loan from General Motors Research Laboratories, Warren, Michigan.

## Pipe & Vessel Detailing (2-4) 3

Design, layout and graphical treatment of piping systems. Emphasis on standard symbols and nomenclature, and schematic, pictorial and multiview representation. Vessels, control and metering devices, and piping materials. Strongly recommended for students planning to enter industries using hydraulic or chemical processes.

| | Topic | Lecture | Laboratory |
|---|---|---|---|
| 1. | Pipe fittings nomenclature | 3 | 4 |
| | a. Pipe | | |
| | (1) sizes | | |
| | (2) wall thicknesses | | |
| | (3) USASI(ASA) schedule numbers | | |
| | b. Fittings | | |
| | (1) standard configurations | | |
| | (2) screwed | | |
| | (3) flanged | | |
| | (4) classes of flanged fittings | | |
| | (5) flange facings | | |
| | (6) welded | | |
| 2. | Single-line orthographic layout | 2 | 6 |
| | a. Piping symbols | | |
| | (1) pipe lines | | |
| | (2) bushings, caps and plugs | | |
| | (3) elbows | | |
| | (4) joints | | |
| | (5) laterals | | |
| | (6) crosses | | |
| | (7) tees | | |
| | (8) reducers | | |
| | (9) valves | | |
| | (10) turn-up and turn-down | | |

Pipe & Vessel Detailing --Continued

b. Orthographic views
    (1) number of views
    (2) visibility
    (3) flaw indication
c. Developed views

3. Double-line orthographic layout 2 5

a. Symbols
    (1) pipe lines
    (2) bushings, caps and plugs
    (3) elbows
    (4) joints
    (5) laterals
    (6) crosses
    (7) tees
    (8) reducers
    (9) valves
b. Orthographic views
    (1) number of views
    (2) visibility

4. Single-line pictorials 2 7

a. Types
    (1) isometric
    (2) oblique
    (3) axonometric
b. Symbols
    (1) pictorial representation
    (2) plane of the symbol
c. Orthographic to pictorial
d. Pictorial to orthographic

5. Pipe and fitting materials 3 3

a. Pipe
    (1) cast iron
    (2) steel
    (3) wrought iron

Pipe & Vessel Detailing--Continued

        (4) brass
        (5) copper
        (6) lead
        (7) galvanized
        (8) plastic
        (9) seamless flexible
        (10) vitreous clay
    b. Fittings
        (1) brass
        (2) iron
        (3) steel
        (4) bronze
    c. Properties
        (1) fabrication
        (2) strength
        (3) chemical properties

6. Joints 3 3

    a. Threaded
        (1) thread types
        (2) when used
    b. Flanged
        (1) types
        (2) standard dimensions
    c. Welded
        (1) when used
        (2) types of welds

7. Sanitary sewers 0 2

    a. Pipe materials used
    b. Flow requirements
    c. Manholes
    d. Plotting profiles

8. Water supply piping 1 2

    a. Flow requirements
    b. Pressure requirements

Pipe & Vessel Detailing--Continued

| | | |
|---|---|---|
| c. Standpipes and tanks | | |
| d. Profiles | | |
| 9. Pipe grades | 2 | 2 |
| a. Bearing, grade and slope | | |
| b. Layouts and flow requirements | | |
| (1) design layout from flow specifications | | |
| (2) computing flow from existing layout | | |
| (3) connections to existing lines | | |
| 10. Building codes and specifications | 0 | 2 |
| a. Requirements for water supply lines | | |
| b. Requirements for sewer lines | | |
| c. Requirements for gas lines | | |
| d. Source, distribution and destination reqirements | | |
| 11. Gas piping | 1 | 3 |
| a. Pipe | | |
| b. Sealing and checking | | |
| c. Control and metering | | |
| d. Safety and pressure relief | | |
| 12. Control and metering devices | 2 | 3 |
| a. Valves | | |
| (1) globe | | |
| (2) gate | | |
| (3) cock | | |
| (4) check | | |
| (5) relief | | |
| b. Gages | | |
| (1) liquid-level | | |
| (2) dial-types | | |

Pipe & Vessel Detailing--Continued

c. Miscellaneous
   (1) filters
   (2) separators
   (3) flow meters
   (4) traps

13. Flow diagrams 3 6

a. Schematic diagrams
   (1) single-view
   (2) block symbols
b. General arrangement drawings
   (1) pictorial representation
   (2) fixture and component representation
   (3) piping representation

14. Vessels 2 4

a. Fabrication
   (1) welded
   (2) riveted
   (3) flanged
b. Configurations
   (1) cylindrical
   (2) spheroidal
   (3) end shapes
c. Pressure characteristics
d. Representation
   (1) orthographic
   (2) pictorial
   (3) sections
   (4) developments

15. Heat exchangers 2 3

a. Operation
   (1) heat flow
   (2) surface exposure
   (3) efficiency

## Pipe & Vessel Detailing--Continued

- b. Fabrication
  - (1) bent tube
  - (2) core
- c. Representation
  - (1) schematic or symbolic
  - (2) simplified
- d. Design
  - (1) heat transfer requirements
  - (2) volume of flow
  - (3) surface exposure

16. Pumps and compressors 2 3

- a. Types
  - (1) centrifugal
  - (2) reciprocating
  - (3) spiral
  - (4) displacement
  - (5) diaphragm
- b. Flow and power requirements
  - (1) flow volume
  - (2) pressure
  - (3) efficiency
  - (4) power required
- c. Representation
  - (1) symbolic
  - (2) simplified
  - (3) detailed

17. Ducting and filtering 1 3

- a. Air ducts
  - (1) rectangular
  - (2) cylindrical
  - (3) routing and layout
  - (4) inlets and outlets
  - (5) plenum chambers
  - (6) developments
  - (7) transition pieces

## Pipe & Vessel Detailing--Continued

b. Filters
    (1) particulate size
    (2) filter materials
    (3) flow loss

18. Fans and blowers 1 2

a. Types
    (1) airfoil-bladed
    (2) squirrel-cage
b. Flow characteristics
    (1) volumetric flow
    (2) efficiency
    (3) size
    (4) driving power required
c. Representation
    (1) symbolic
    (2) simplified
    (3) detailed

19. Sewage treatment 0 1

a. Common methods
    (1) settling
    (2) aeration
    (3) filtering
    (4) bacterial action
b. Configurations
    (1) settling tanks
    (2) air supplies
    (3) agitation
c. Representation
    (1) schematic diagrams
    (2) arrangement diagrams

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Pipe & Vessel Detailing--Continued

Suggested Texts:

Crocker, Piping Handbook, 1945, McGraw-Hill

D'Arcangelo, Blueprint Reading, Plumbing Trades, 1963, Delmar

Littleton, Industrial Piping, 2nd Edition, 1962, McGraw-Hill

Thompson, Fundamentals of Pipe Drafting, 1958, Wiley

Additional Recommended References:

USASI (ASA Standards BZ.1, B16a, B16e, B16.9, B36.10, B36.19, Z32.2.3

Special Equipment or Facilities Recommended:

Samples of typical pipe fittings

Samples of industrial piping drawings

Opportunity to visit a piping fabrication shop, or industry such as chemical or refinery would be beneficial. Alternatively, a visit to the local power generation plant might be arranged.

## Sheet Metal Drafting (2-4) 3

Design and layout of patterns for fabrication from sheet materials. Emphasis on theory of developments, sheet materials, forming processes, and use of standard forming tables. Recommended for students planning to enter industries in which sheet construction is used, such as aircraft skin structures, pressure vessels, or metal cabinetry.

| Topic | Lecture | Laboratory |
|---|---|---|
| 1. Auxiliary views-review | 4 | 7 |
|   a. Primary auxiliary views | | |
|     (1) orthographic views | | |
|     (2) line of sight | | |
|     (3) reference planes/lines | | |
|     (4) projection and measurement | | |
|   b. Successive (oblique) auxiliary views | | |
|     (1) planes of projection | | |
|     (2) line of sight | | |
|     (3) projection and measurement | | |
|   c. Applications | | |
|     (1) true length of a line | | |
|     (2) point view of a line | | |
|     (3) edge view of a plane | | |
|     (4) point view of aline | | |
|     (5) tree shape of a plane | | |
|     (6) projecting curves. | | |
| 2. Rotation | | |
|   a. Fundamentals | 3 | 6 |
|     (1) views of axis of rotation | | |
|     (2) path of a rotating point | | |
|   b. True length of a line by rotation | | |
|     (1) cone of revolution | | |
|     (2) position of line for true-length | | |
|   c. The true length diagram | | |
|   d. True shape of a plane surface by revolution | | |

Sheet Metal Drafting--Continued

- (1) primary auxiliary edge view
- (2) position for true shape

3. Lettering 3 6

(The student should not require formal instruction in lettering, since it has been received in prerequisite courses. It is suggested the time allotted here be used for remedial instruction and supervision if necessary, and distributed throughout the course.)

4. Theory of developments 7 11

- a. Review of fundamentals
  - (1) parallel-line development
  - (2) radial-line development
  - (3) triangulation
- b. Prisms and cylinders--parallel-line development
  - (1) rectangular ducts and elbows
  - (2) cylindrical ducts and elbows
  - (3) seam and pattern arrangement in stock material
  - (4) compound curved ducts and elbows
  - (5) transitional ducts--rectangular
  - (6) offset ducts
  - (7) prism and cylinder intersections
  - (8) Tees, Y's and breeching
  - (9) cornices and gutters
- c. Conical developments--radial-line
  - (1) right circular cone pattern
  - (2) cone frustum and truncated cone
  - (3) oblique cones
  - (4) conical reducing elbows
  - (5) cone intersections
  - (6) conical approximation of double-curved surfaces
  - (7) pyramid developments

Sheet Metal Drafting--Continued

- d. Warped surfaces--triangulation
  - (1) hyperbolic paraboloid
  - (2) twisted ducts
  - (3) transitions
  - (4) the cylindroid
  - (5) the conoid
  - (6) offset transitions
  - (7) transition elbows
- e. Branch fittings
  - (1) two-branch
  - (2) multiple-branch
- f. combination fittings

| | | |
|---|---|---|
| 5. Dimensioning | 3 | 6 |

- a. Review fundamentals
  - (1) nomenclature
  - (2) lettering
  - (3) placement
- b. Part drawings
  - (1) basic dimensions
  - (2) fabrication notes
- c. Pattern drawings
  - (1) stretchout or developed length of bent parts
  - (2) bend allowance for thick material

| | | |
|---|---|---|
| 6. Sheeting materials | 2 | 5 |

- a. Materials
  - (1) iron and steel
  - (2) copper, aluminum and other non-ferrous materials
- b. Standard sheet-metal gages and thicknesses
  - (1) gage numbers
  - (2) Brown and Sharpe
  - (3) American Steel and Wire Co.

Sheet Metal Drafting--Continued

    (4) Birmingham or Stubs
    (5) Music wire
    (6) Imperial wire gage
    (7) U.S. Standard plate

7. Farming processes and machines 2 5

    a. Cutting
        (1) squaring shears
        (2) ring and circle shears
    b. Folding and bending
        (1) bar folders
        (2) sheet folders
        (3) pipe folders
        (4) brakes and molds
    c. Drilling
    d. Forming
        (1) slip rollers
        (2) turning machines
        (3) wiring machines
        (4) burring machine
    e. Seaming and edging
        (1) setting-down machine
        (2) double-seam machine
        (3) crimping and beading
        (4) grooved seams
        (5) dovetail seams
        (6) flanges
    f. Assembly methods
        (1) soldering
        (2) riveting
        (3) sheet-metal screws

8. Edge-margin requirements 2 5

    a. Edges
        (1) single-hem
        (2) double-hem
        (3) wired

Sheet Metal Drafting--Continued

| | | |
|---|---|---|
| b. Seams | | |
| (1) lap | | |
| (2) grooved | | |
| (3) lock | | |
| c. Notching | | |
| (1) square | | |
| (2) straight | | |
| (3) slant | | |
| (4) vee | | |
| (5) wire notch | | |
| 9. Templates | 2 | 3 |
| a. Uses | | |
| b. Materials | | |
| c. Production | | |
| (1) drawings for templates | | |
| (2) machine tooling | | |
| (3) stamping and punching | | |
| 10. Stampings | 2 | 5 |
| a. Stamped parts | | |
| (1) uses | | |
| (2) materials | | |
| b. Drawings | | |
| (1) dimensioning | | |
| (2) dimensional stability | | |
| 11. Tooling for stampings | 2 | 5 |
| a. Physical requirements | | |
| (1) dimensional control | | |
| (2) contour edge quality | | |
| b. Punch and die design | | |
| (1) shear forces required | | |
| (2) geometry of punch and die | | |
| (3) point of force application | | |
| (4) hydraulic and mechanical presses | | |
| TOTALS | 32 | 64 |

Sheet Metal Drafting--Continued

Suggested Texts:

Betterley, Sheet Metal Drafting, 1961, McGraw-Hill

Additional Recommended References:

Stieri, Sheet Metal Principles and Procedures, 1953, Prentice-Hall

Special Equipment or Facilities Recommended:

Opportunity to visit sheet-metal production shop and punch-die design shop would be beneficial.

## Structural Drafting I (2-4) 3

A first course in methods and techniques of representation and elementary design of conventional steel structural components. Extensive use of standard tables and specifications for selection and representation of components for typical structures. Methods of scheduling and estimating materials. Introduction to detailing reinforced concrete components.

| Topic | Lecture | Laboratory |
|---|---|---|
| 1. Steel fabrication and shapes | 3 | 6 |
| a. Methods of fabrication | | |
| (1) rolling | | |
| (2) cutting | | |
| (3) punching and drilling | | |
| (4) templates | | |
| b. Standard shapes | | |
| (1) beams and columns | | |
| (2) channels | | |
| (3) angles | | |
| (4) tubing and pipe | | |
| (5) plates and bars | | |
| (6) detailing shapes | | |
| (7) special shapes | | |
| 2. Aluminum fabrication and shapes | 2 | 4 |
| a. Fabrication | | |
| (1) rolling | | |
| (2) extruding | | |
| (3) drawing | | |
| b. Standard shapes | | |
| (1) angles | | |
| (2) I-beams | | |
| (3) channels | | |
| (4) wide-flange sections | | |
| (5) T-sections | | |
| (6) Z-sections | | |
| (7) bulb angles | | |

Structural Drafting I--Continued

(8) bars, rods, plate and sheet
(9) tubing and pipe
(10) special sections
c. Use of Alcoa handbook

3. Structural fasteners 3 6

a. Steel fasteners
(1) rivet details
(2) bolt details
(3) drilling and punching
(4) setting and tightening
b. Aluminum fasteners
(1) rivet details
(2) bolt details
(3) drilling and punching
(4) setting and tightening
c. Allowable loads
d. Joint design
(1) structural loading
(2) shear, tension and bearing
(3) fastener patterns
e. Welded joint details

4. Use of A.I.S.C. Handbook 3 6

a. Dimensions and properties
(1) designations
(2) dimensions
(3) weights
(4) section properties
b. Beam and girder design
(1) span
(2) loading
(3) supports
(4) allowable loads
c. Column design
(1) loading
(2) end restraints
(3) slenderness ratio

(4) allowable loads
(5) base plate design and detailing

d. Connections
(1) allowable loads on fasteners
(2) framed
(3) seated
(4) special
(5) eccentric
(6) welded
(7) detailing

e. Specifications and Codes
(1) design, fabrication and erection
(2) A.I.S.C. Code of Standard Practice
(3) live loading
(4) exposed steel
(5) open web steel joists
(6) structural joints

f. Miscellaneous data and tables

5. Use of Smoley's Four Combined Tables 2 4

a. Logarithims and squares
b. Slopes and rises
c. Trigonometric tables
d. Segmental functions

6. Shear, moment and deflection diagrams 3 6

a. Simple beams
(1) uniform loads
(2) concentrated loads

b. Cantilever beams
(1) uniform loads
(2) concentrated loads

c. End supports and reactions
(1) fixed
(2) free deflection
(3) free rotation

d. continuous beams

Structural Drafting I--Continued

   e. Concentrated moving loads
   f. Camber and deflection coefficients

7. Truss analysis and design 3 6

   a. Loading and reactions
   b. Types of trusses
      (1) Warren
      (2) Pratt
      (3) Howe
      (4) Fink
      (5) cantilevered
      (6) special trusses
   c. Reactions and member loads
      (1) Bow's notation
      (2) string and funicular polygons
      (3) Maxwell diagram
      (4) tension and compression
      (5) Method of sections
      (6) indeterminate trusses--substitute member method
   d. Gusset plate design
      (1) loading
      (2) size and number of fasteners
      (3) plate thickness and configuration

8. Steel beam design and selection 3 6

   a. Structural requirements
      (1) geometry and configuration
      (2) loading and supports
   b. Selection
      (1) from A.I.S.C. standard tables
      (2) allowable moment and shear
   c. Design
      (1) fabricated beams and girders
      (2) double-angle struts
      (3) plate girders

Structural Drafting I--Continued

        (4) stiffeners and end plates
        (5) splices
    d. Detailing standard and fabricated members

9. Steel column design and details 3 6

    a. Loading configurations
        (1) concentric
        (2) eccentric
        (3) end restraints
    b. Column fabrication
        (1) standard shapes
        (2) fabricated columns
        (3) base plates
    c. Column splices
    d. Detailing
        (1) column fabrication
        (2) connections and base plates

10. Steel connection details 3 6

    a. Shear connections
        (1) framed
        (2) seated
    b. Skewed connections
        (1) single- and double-angle
        (2) bent plate
    c. Moment connections
    d. Erection details
        (1) coping and clearances
        (2) gauges
    e. Pinned joints
        (1) pins
        (2) reinforcing plates
    f. Supports
        (1) pedestals
        (2) base plates
        (3) grillage footings

Structural Drafting I--Continued

| | | |
|---|---|---|
| 11. Reinforced concrete terminology | 2 | 4 |
| a. Poured-in-place | | |
| (1) pouring and smoothing | | |
| (2) steel placement and support | | |
| (3) forms | | |
| b. Precast and prestressed forms | | |
| (1) precast manufacture | | |
| (2) prestressing and its purpose | | |
| (3) beams and girders | | |
| (4) slabs and paving | | |
| (5) concrete pipe | | |
| 12. Reinforcing steel | 2 | 4 |
| a. Bars | | |
| (1) standard sizes | | |
| (2) hooks and bevels | | |
| (3) slants | | |
| b. Stirrups | | |
| (1) uses | | |
| (2) standard shapes | | |
| c. Fireproofing | | |
| d. Bar supports | | |
| e. Column ties | | |
| f. Steel placement detailing | | |
| TOTALS | 32 | 64 |

Suggested Texts: See next page

Structural Drafting I--Continued

Suggested Texts:

Structural Steel Detailing, 1966, American Institute of Steel Construction

Manual of Steel Construction, Sixth Edition, 4th Revision, 1967, American Institute of Steel Construction (AISC)

Additional Recommended References:

Smith, Principles and Practices of Heavy Construction, 1967, Prentice-Hall

## Structural Drafting II (2-4) 3

A continuation of Structural Drafting I, placing additional emphasis on advanced detailing and design of concrete and steel structural components. Discussion of modern structural trends utilizing cable-supported and shell structures.

| Topic | Lecture | Laboratory |
|---|---|---|
| 1. Reinforced concrete properties | 2 | 4 |
| a. Composition and manufacture | | |
| b. Steel | | |
| (1) tension | | |
| (2) temperature | | |
| (3) stirrups | | |
| (4) ties | | |
| (5) bar supports | | |
| (6) welded mesh | | |
| c. Structural components | | |
| d. Beams, girders and joists | | |
| e. Slabs | | |
| f. Columns | | |
| 2. Reinforcing steel and placement | 3 | 6 |
| a. Bars | | |
| (1) standard sizes | | |
| (2) hooks and bevels | | |
| (3) slants | | |
| b. Stirrups and ties | | |
| (1) uses | | |
| (2) standard shapes | | |
| c. Wire mesh | | |
| d. Steel supports | | |
| (1) bolsters | | |
| (2) bar chairs | | |
| (3) slab supports | | |
| e. Fireproofing and weathering | | |
| f. Relation to beam width | | |
| g. Relation to aggregate size | | |

Structural Drafting II--Continued

| | | |
|---|---|---|
| 3. Earth-supported slabs | 2 | 4 |
| a. Excavation of site | | |
| b. Cushioning of slab | | |
| c. Forms | | |
| d. Steel placement | | |
| e. Steel supports | | |
| f. Thickness and surface finish | | |
| g. Detailing a typical slab | | |
| 4. Curbs and gutters | 2 | 4 |
| a. Shapes and forms | | |
| b. Steel placement and support | | |
| c. Inlet boxes | | |
| d. Detailing | | |
| 5. Symbols, standards and marks | 2 | 4 |
| a. Buildings | | |
| (1) beam and slab symbols | | |
| (2) floor designation | | |
| (3) columns and footings | | |
| b. Bridges | | |
| (1) station numbers | | |
| (2) wall and girder designation | | |
| (3) miscellaneous structures | | |
| 6. Beam, slab and column joint details | 3 | 6 |
| a. Concrete-to-concrete | | |
| (1) slab to beam | | |
| (2) beam to beam | | |
| (3) beam to column | | |
| (4) slab to column | | |
| (5) slab to wall | | |
| (6) beam to wall | | |
| b. Concrete-to-steel | | |
| (1) steel beams on concrete | | |
| (2) concrete slabs | | |

## Structural Drafting II--Continued

| | | |
|---|---|---|
| 7. Concrete floor details | 3 | 6 |
| a. Types | | |
| (1) slab | | |
| (2) joist | | |
| (3) waffle | | |
| (4) beam and girder | | |
| (5) two-way slab and beam | | |
| b. Engineering drawings | | |
| (1) use | | |
| (2) information contained therein | | |
| c. Placement drawings | | |
| (1) use | | |
| (2) information contained therein | | |
| d. Schedules | | |
| (1) beam and girder | | |
| (2) slab | | |
| (3) steel | | |
| 8. Concrete walls | 3 | 6 |
| a. Main building walls | | |
| b. Retaining walls | | |
| (1) cantilever | | |
| (2) counterfort | | |
| c. Footings | | |
| d. Foundations | | |
| e. Skewed headwall culverts | | |
| 9. Drilled footings and foundation columns | 2 | 4 |
| a. Earth forms | | |
| b. Steel placement | | |
| c. Detailing | | |
| 10. Beam detailing from schedules | 2 | 4 |
| a. Information in schedule | | |
| (1) identification marks | | |

- (2) size
- (3) steel specifications

b. Detailing beams from schedule information and framing plan

11. Beam detailing from design drawings 3 6

    a. Advantages
    b. Relation of steel placement to beam moments

12. Scheduling

    a. beams and girders
        (1) identification
        (2) steel specifications
    b. slabs
    c. joists
    d. steel bending schedule
    e. column and footing schedules

13. Concrete shell structures 2 4

    a. Form materials
        (1) wood
        (2) steel mesh
    b. Shell application
        (1) pouring
        (2) spraying
    c. Shell supports
        (1) tension rings
        (2) c
        (3) cable systems
    d. Shapes
        (1) spherical domes
        (2) paraboloids
    e. Detailing

### Structural Drafting II--Continued

| | | |
|---|---|---|
| 14. Field trips | 1 | 2 |
| a. Steel construction sites | | |
| b. Concrete pouring operations | | |
| TOTALS | 32 | 64 |

Suggested Text:

A.C.I. Committee, E.E. Rippstein, Chairman, ACI Standard 315-65 Manual of Standard Practice for Detailing Reinforced Concrete Structures, 1965, American Concrete Institute (ACI)

## Technical Illustration I (2-4) 3

Design and layout of patterns for fabrication from sheet materials. Emphasis on theory of developments, sheet materials, forming processes, and use of standard forming tables. Recommended for students planning to enter industries in which sheet construction is used, such as aircraft skin structures, pressure vessels, or metal cabinetry.

| Topic | Lecture | Laboratory |
|---|---|---|
| 1. Projection fundamentals | 3 | 7 |
| a. Projection fundamentals | | |
| b. Projectors | | |
| c. Points, lines and surfaces | | |
| d. Parallel projection | | |
| e. Central projection | | |
| 2. Axonometric projection | 5 | 12 |
| a. Isometric | | |
| (1) line of sight | | |
| (2) position of axes | | |
| (3) foreshortening | | |
| (4) angles | | |
| (5) curves | | |
| (6) elipses | | |
| (7) projection vs. drawing | | |
| b. Dimetric and Trimetric | | |
| (1) lines of sight | | |
| (2) positions of axes | | |
| (3) axis scales | | |
| (4) angles and curves | | |
| (5) elipses | | |
| (6) pseudc-pictorials | | |
| c. Exploded pictorial assemblies | | |

Technical Illustration I--Continued

| | | |
|---|---|---|
| 3. Oblique drawing | 2 | 3 |
| a. Line of sight | | |
| b. Types of oblique | | |
| (1) cavalier | | |
| (2) cabinet | | |
| (3) angular | | |
| c. Projection vs. drawing | | |
| d. Advantages and disadvantages of oblique | | |
| e. Angles, curves and ellipses | | |
| f. Exploded assemblies | | |
| 4. Perspective drawing | 2 | 5 |
| a. Terminology | | |
| (1) picture plane | | |
| (2) grained line | | |
| (3) station point | | |
| (4) horizon | | |
| (5) center of vision | | |
| (6) vanishing points | | |
| b. Types | | |
| (1) parallel or one-point | | |
| (2) two-point | | |
| (3) three-point | | |
| c. Methods | | |
| (1) vanishing point | | |
| (2) measuring points | | |
| (3) perspective plan | | |
| (4) perspective grids | | |
| d. Circles and other curves | | |
| e. Inclined and oblique lines | | |
| f. Exploded assemblies | | |
| 5. Shade and shadow | 1 | 3 |
| a. Standard light source | | |
| b. Elementary shading | | |

Technical Illustration I--Continued

- (1) rectangular shapes
- (2) cylinder
- (3) cone
- (4) sphere
- (5) combinations

c. Techniques
  - (1) line shading
  - (2) cross-hatching
  - (3) smudge shading

d. Shadows
  - (1) point on a plane
  - (2) line on a plane
  - (3) points on a curved surface
  - (4) solids in combination
  - (5) techniques

e. Shade and shadow in perspective
  - (1) light sources
  - (2) vanishing shadow points

6. Pencil rendering 2 3

   a. Shape delineation
      - (1) plane surfaces
      - (2) curved surfaces
      - (3) fillets and rounds
      - (4) threads

   b. Surface texture
      - (1) polished
      - (2) rough

   c. Materials representation
      - (1) metallic
      - (2) non-metallic

7. Ink rendering 2 5

   a. Use of technical fountain pens
      - (1) line widths and point sizes
      - (2) use and maintenance

Technical Illustration I--Continued

| | | |
|---|---|---|
| b. Freehand techniques | | |
| (1) brush | | |
| (2) crow-quill pen | | |
| (3) stippling | | |
| c. Special equipment | | |
| (1) templates | | |
| (2) lettering guides | | |
| 8. Shading films | 3 | 3 |
| a. Types | | |
| b. Patterns | | |
| c. Application | | |
| 9. Transfer or cut-out lettering | 3 | 5 |
| a. Dry-transfer types | | |
| b. Cut-out types | | |
| c. Styles and fonts | | |
| d. Point sizes | | |
| e. Composition and application | | |
| f. Non-alphabetic symbols | | |
| 10. Wash rendering | 1 | 1 |
| a. Selection of paper | | |
| b. Water colors and ink | | |
| (1) tonal gradation | | |
| (2) dry-brush technique | | |
| 11. Airbrush | 1 | 3 |
| a. Types and nomenclature | | |
| b. Adjustment and maintenance | | |
| c. Control and effects | | |
| (1) air flow | | |
| (2) ink or paint flow | | |
| (3) spray size | | |
| (4) spray fineness | | |

Technical Illustration I--Continued

d. Pressure sources
    (1) air compressors
    (2) gas cylinders
e. Masking and friskets
    (1) materials
    (2) application
f. Techniques
    (1) lines
    (2) shaded areas
    (3) highlighting

12. Coquille board 0 1

a. Textures
b. Application to line-cut reproduction
c. Lithograph and Conte crayon
d. Ink on coquille board

13. Scratchboard 0 1

a. Techniques
b. Uses

14. Double-tone, or Craftint 0 1

a. Patterns
b. Chemicals
c. Techniques
d. Uses

15. Layouts for publication 1 2

a. "Dummy" layout
b. Line-cuts
c. Photo masking and cropping
d. "Mechanical" layout
e. Reduction and enlargement

Technical Illustration I--Continued

| | | | |
|---|---|---|---|
| 16. | Half-tone process | 1 | 1 |
| | a. Uses | | |
| | b. Standard screens | | |
| | c. Reduction and enlargement | | |
| | d. Cropping and masking | | |
| 17. | Color separation | 1 | 2 |
| | a. masking | | |
| | b. registration | | |
| 18. | Charts and graphs | 1 | 1 |
| | a. Review of formats and techniques | | |
| | b. Use of films, chart tapes and prepared lettering | | |
| 19. | Technical sketching | 0 | 1 |
| | a. Review techniques | | |
| | b. Application to illustration layouts | | |
| 20. | Typeset reproduction | 0 | 1 |
| | a. Standard and special fonts | | |
| | b. Comparison with offset | | |
| 21. | Artist's materials | 1 | 1 |
| | a. Papers and films | | |
| | b. Inks, colors, pens, brushes | | |
| | c. Special equipment | | |
| 22. | Reproduction processes | 0 | 1 |
| | a. Electrostatic | | |
| | b. Photo-offset | | |
| | c. Photo-engraver | | |
| | d. Color processes | | |

Technical Illustration I--Continued

23. Military standards and reference materials 2 1

- a. Military standards
- b. Industrial standards

TOTALS 32 64

Suggested Texts:

Gibby, Technical Illustration 2nd Edition, 1970, American Technical Society

Hoelscher, Spring, and Pohle, Industrial Production Illustration, 1946, McGraw-Hill

Thomas, Technical Illustration, 1960, McGraw-Hill

Additional Recommended References:

Cholet, The All-American Art--Cartooning, 1960, Higgins Ink Co.

Kinghan, Rendering Techniques for Commercial Art and Advertising, 1964, Reinhold

McCartney, Precision Perspective Drawing, 1963, McGraw-Hill

Special Equipment or Facilities Recommended:

Air-brush equipment: compressed-gas supply (CO$_2$ tanks recommended for economy, portability and convenience), and air brushes (Paasche and Thayer and Chandler are two well-known and recommended manufacturers).

## Technical Illustration II (2-4) 3

A continuation of Technical Illustration I, with additional emphasis placed upon advanced techniques such as airbrush, photoretouching and color separation. Intended primarily to develop individual student ability and illustrating skills.

| Topic | Lecture | Laboratory |
|---|---|---|
| (Since this course is intended primarily to develop individual skill through practice it is suggested that the classes be devoted to the pursuit of individual projects, with close supervision and periodic critiques, and demonstrations by students, instructor and professional illustrators where possible.) | | |
| TOTALS | 32 | 64 |

Suggested Texts and References:

(See listing for Technical Illustration I, page

Personnel Requirements

Of the twenty-one Texas schools reporting, the number of instructors teaching D & DT courses ranged from one in a program of 89 students through three in a program of 300 students to six in a program of 26 students. It is evident that the enrollment in such programs is not the only factor in determining staffing requirements.

A great deal depends upon scheduling of classes and room utilization, as well as upon enrollment. For example, consider a program with 180 students in one course, meeting 6 hours a week. If a single classroom can accomodate 30 students, then 180/30 = 6 sections of the course are needed. Thus 6 sections times 6 hours a week per section equals 36 hours a week room utilization. One full-time instructor could theoretically teach these 6 sections, and have 4 hours a week left over for class preparation, (assuming a 40-hour week) provided that the 6 sections could be scheduled without conflict!

The foregoing example obviously represents an undesirable situation, since 4 hours preparation time per week for 6 sections is not enough, and it is unlikely that the 6 sections could be scheduled without conflict. Moreover, instructors in many schools teach courses other than in Drafting and Design, and are not available to teach a single course all the time.

Thus it can be seen that both staffing requirements and classroom requirements must be planned together, and will depend upon both enrollment and scheduling. It is suggested that an initial estimate of staffing requirements be made based upon estimated D & DT enrollment, and that the staffing estimate then be re-examined after establishing trial class schedules for the proposed program.

Specialty courses will require teaching personnel trained in those specialties. This may or may not require additional instructors, depending upon individual competence. One solution is to utilize teaching personnel all of whom are capable of teaching one or more of the specialty courses to be offered, and who presumably can also teach the more general, non-specialized course. In this way, duplication of personnel can be avoided.

A staffing estimation form has been provided to assist in making an initial estimate of drafting teaching staff requirements, using the estimated enrollment figure obtained earlier from Form II-B-1, II-B-2, or II-B-3, as appropriate. The specialty courses to be included in the program are considered from the total program content previously determined (pp. 36-38). The estimate of the number of specialist instructors needed will be highly subjective, depending upon individual teacher competence in various specialties, and also upon enrollment size within a specialty. As a rough estimate, it is suggested that one specialist instructor be counted for each different specialty course listed.

The form makes the assumption that specialist instructors can also teach general drafting courses. Instructors needed for non-drafting courses are not considered here, as it is assumed that they will be provided by other departments who administer the non-drafting courses in the program. Needless to say, a great deal of coordination is necessary between the drafting department and other departments throughout the entire planning process, particularly where personnel utilization is concerned.

The estimated total number of drafting personnel needed by no means indicates a final figure, since scheduling and room utilization will interact with instructor availability, and these in turn will depend upon enrollment and classroom availability.

TURN TO FORM II-D-1 to estimate teaching staff requirements.

FORM II-D-1

EXAMPLE

USE THIS FORM TO MAKE AN INITIAL ESTIMATE OF THE NUMBER OF FULL-TIME DRAFTING INSTRUCTORS NEEDED.

Estimated D & DT Enrollment from line (A) of enrollment prediction form II-B-1, II-B-2, or II-B-3, as appropriate . . . . . . . . . . . . 65 (1)

Initial estimate of number of instructors needed (.024 of line (1), raised to next whole number) . . . 2 (2)

Specialty Drafting Courses to be offered (Form II-C-3, page 38):

BUILDING CONTR. DFTG II
STRUCTURAL DFTG II
TECH. ILLUS. I
TECH. ILLUS. II
COMPUTER GRAPHICS
MACHINE & TOOL DESIGN
CARTOGRAPHY
SHEET METAL DFTG.
PIPING DFTG.
FOUNDRY DRFTG.
GRAPHICAL ANALYSIS

Estimated number of specialty instructors (assume one for each unique specialty area) needed to teach the above courses . . . . . . 5 (3)

Estimated number of additional general instructors needed (line (2) minus line (3), but not less than zero) . . 0 (4)

Estimated total number of instructors needed (line (3) plus line (4) ) . . . . . . . . . . . . . . 5 (5)

TURN TO PAGE 189 for a discussion of facilities and equipment.

## Facilities and Equipment

Before proceeding into this phase of the program planning, it is most important to realize that the determination of teaching staff requirements, scheduling, room utilization, room availability and instructor utilization are so interrelated that any final decisions made upon these must be as a result of an iterative process. An analogy can be made to the mathematical iterative process often used in solving equations; a solution is assumed, then this solution is used to obtain a better (more nearly correct) solution, then this solution is used to obtain still another, and so on. The process is halted when a successive iteration fails to provide a better solution than the previous one. A similar process must be used here, although it is more difficult in that there is no formal "equation" to work with.

The best that can be done is to assume certain "solutions" regarding teaching staff, enrollment, and number of classrooms needed. These assumptions are then examined together with possible scheduling schemes, and modified so as to obtain a workable system. This procedure will vary so much from school to school that no specific guidelines can be presented here. It is possible that the availability of a moderately-sized computer, along with personnel versed in operations research and optimization theory can be of great assistance.

Forms have been provided to assist in making an initial estimate of the number of drafting rooms needed. If an excessive figure results, it may be reduced by enlarging section (class) size up to that which one instructor can handle efficiently, and which a given room can accomodate (the maximum recommended is 30 students per section.) Another way is to attempt to schedule drafting courses evenly distributed from semester to semester throughout the entire course of study so that a minimum number of different drafting courses are taken by the same students in any one semester. Still another way to reduce the number of rooms needed is to increase room utilization to a maximum value; a normal maximum limit would be 40 hours per week per room, figuring an 8:00 to 12:00, 1:00 to 5:00 school day, Monday through Friday, although scheduling conflicts with other courses rarely permit the attainment of this limit. A more practical figure would be 30 to 35 hours per week for each room.

It must be kept in mind that if small sections are desired from an instructional viewpoint, then both number of rooms and number of instructors needed will increase. The size of sections deemed desirable will also affect the size of the drafting rooms needed.

The following pages present a discussion of various considerations to be made concerning location, layout, furnishings and size of drafting rooms, based upon recommendations obtained from the survey of drafting facilities now in use throughout the state. It is suggested that these pages be examined briefly before proceeding to formalize the next planning phase. In this way, reference can more easily be made to them as needed later.

The remaining portions of the planning section give recommendations concerning instructors' offices, drafting equipment (exclusive of tables and chairs), illumination, storage, educational enrichment, reproduction equipment, and audio-visual and other teaching aids. Photographs of typical installations and a representative equipment price list are also included for the user's information. Forms are provided to assist in estimating the total cost of equipment, exclusive of the cost of the rooms themselves. When the use of existing buildings or rooms is planned, a careful check should be made of illumination level so as to insure adequate lighting to avoid discomfort, and provision for correct lighting should of course be made if new classrooms are contemplated.

TURN TO FORM II-E-1, page 192, to estimate the number of drafting rooms needed.

## FORM II-E-1

## ESTIMATION OF NUMBER OF DRAFTING ROOMS NEEDED

EXAMPLE

D & DT Enrollment (from Form II-B-1, II-B-2, or II-B-3) . . . . . . . . . . . . . . . . . . . . . . 65 (1)

Divide line (1) by the average number of students per section . (20) . . . . . . . . (65 ÷ 20) . . . 3.25 (2)

Maximum number of different drafting courses scheduled for the same students in any one semester. . . . . 3 (3)

Multiply line (2) by line (3) . (3.25 × 3) . . . . . . 9.75 (4)

Average room utilization, hours per week per room. . . 30 (5)

Average number of clock hours per week for one section 6 (6)

Divide line (5) by line (6) . . . . (30 ÷ 6) . . . . 5 (7)

Divide line (4) by line (7); round to next whole number. 2 (8)
(9.75 ÷ 5)

The last figure, line (8), is an estimate of the number of rooms needed. Note that an excessive number of rooms needed may be reduced by any or all of the following:

1. Enlarging section size (line (2) )
2. Reducing the multiplicity of courses scheduled per semester (line (3) )
3. Increasing room utilization (line (5) )

TURN TO PAGE 193 for a discussion of drafting room facilities.

## Location of Drafting Room

The location of a drafting laboratory in relation to other rooms within a building is not of particular importance, especially when windowless drafting rooms are constructed. Most drafting personnel who were teaching in rooms with no windows were of the opinion that windowless drafting rooms were desirable. However, if windows are planned for drafting facilities, it is strongly recommended that they be small and adequately furnished with window covers so the room can be properly darkened when needed.

Recommendation.--A drafting room should be constructed with no windows or with small windows that are adequately covered so the room can be darkened.

## Doors

Doors leading into a drafting room should be sufficiently wide to allow for ease of entering and exiting the room. Doors four feet wide will allow sufficient opening for the installation of new machines and equipment and for moving student projects in and out of the drafting room.

Recommendation.--The entrance doors to drafting rooms should be at least four feet wide.

Flexibility

Flexibility of drafting facilities should be considered. For example, in facilities that have more than one drafting room, accordian walls can be located between drafting rooms to allow for fluctuations in class enrollments. Flexibility is particularly important in larger programs where several drafting rooms and instructors are present. Accordian walls should not only be considered between drafting rooms but also between a drafting room and a classroom used for lecturing purposes. A trend in many educational disciplines is to have large group lectures and small group study or work groups. If this trend is promoted, flexibility will be needed.

Recommendation.--Flexibility between drafting rooms and between drafting rooms and classrooms should be considered, especially for multi-room facilities and for future expansion.

Floor Covering

The majority of floor coverings in the drafting rooms of Texas are asphalt or vinyl tile. However, one college had wall to wall carpets and the drafting personnel at this college were very pleased with it. Research revealed that carpets add greatly to the warmth and acoustical qualities of a room. It is suggested that the carpets be investigated before deciding on floor coverings. Research indicated that carpets are competitive in price with tile, especially when the benefits of carpet are taken into consideration.

Recommendation.--Data indicated that vinyl or asphalt tile should be used as floor covering; however, it is suggested that carpet be investigated before making a final decision.

### Width of Aisles

When planning the size of a drafting room, consideration should be given to the width of aisles, number of work stations, and the amount of floor space per student. Table 1 gives the minimum, adequate, and optimum width of aisles for a drafting room.

Recommendation.--See Table 1.

### Number of Drafting Tables

The number of tables recommended for a drafting room is shown in Table 2. The table shows the minimum, adequate,

## TABLE 1

## WIDTH OF AISLES

| | Width of Aisles (inches) |
|---|---|
| Minimum | 30 |
| Adequate | 36 |
| Optimum | 48 |

## TABLE 2

## NUMBER OF WORK STATIONS FOR BEGINNING AND ADVANCED DRAFTING ROOMS

| | Beginning Laboratory | Advanced Laboratory |
|---|---|---|
| Minimum | 20 | 18 |
| Adequate | 24 | 20 |
| Optimum | 30 | 24 |

and optimum number of tables for a beginning and advanced drafting room.

Recommendation.--See Table 2.

## Floor Space per Student

The suggested square footage of floor space per student is shown in Table 3 for beginning and advanced drafting rooms. The footage is based on thirty work stations for a beginning laboratory and twenty-four stations for an advanced drafting room.

Recommendation.--See Table 3.

## Suggested Layout for Drafting Rooms

A suggested layout for beginning and advanced drafting rooms is shown in Table 4. The recommendations are based on the suggestions and recommendations of drafting personnel of Texas junior colleges. (Note that no special distinction need be made between beginning and advanced drafting room sizes, as they differ only by two feet in width.) Samples of drafting room layouts are shown on pages 199 and 200.

TABLE 3

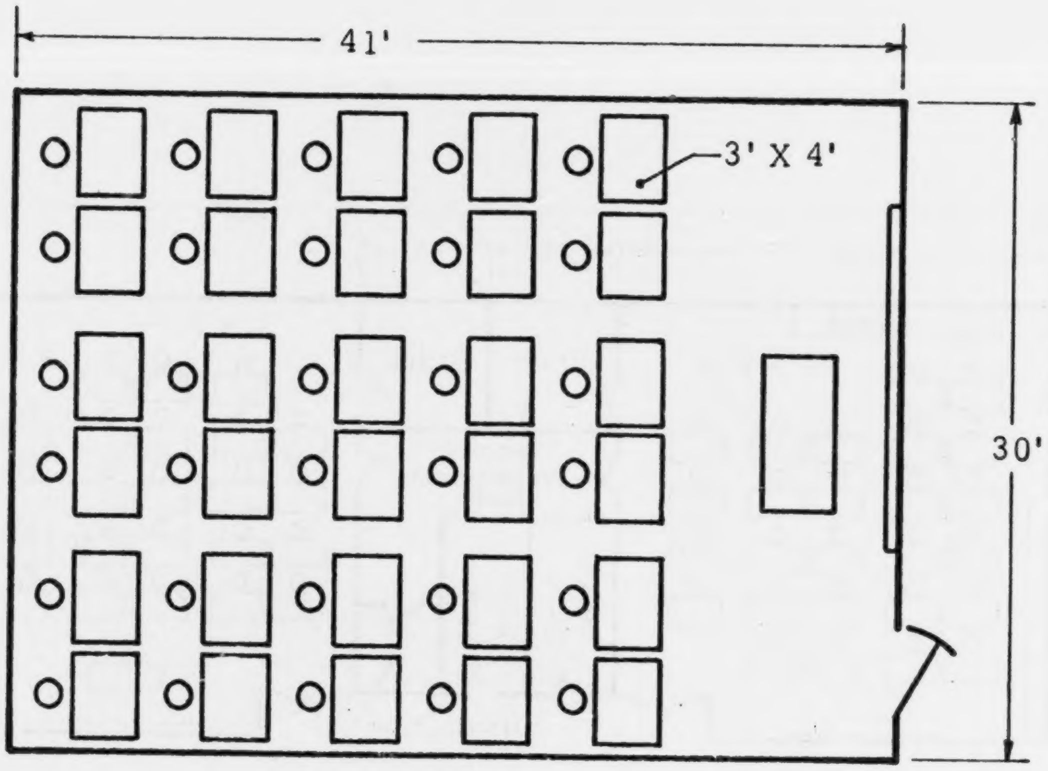
SQUARE FOOTAGE PER STUDENT

| | Beginning Laboratory | Advanced Laboratory |
|---|---|---|
| Minimum | 45 | 60 |
| Adequate | 55 | 75 |
| Optimum | 65 | 84 |

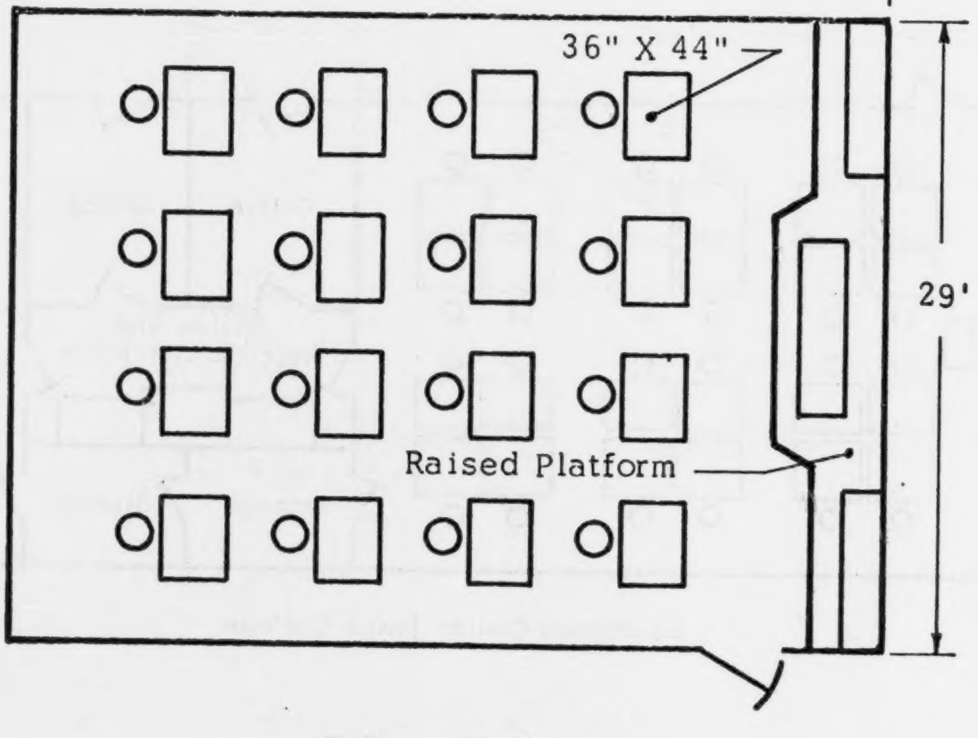
TABLE 4

RECOMMENDATIONS FOR A BEGINNING AND ADVANCED DRAFTING LABORATORY

| | Beginning Laboratory | Advanced Laboratory |
|---|---|---|
| Room Dimensions | | |
| Width | 38' | 40' |
| Depth | 50' | 50' |
| Square Feet of Floor Space Per Student | 65 Sq. Ft. | 84 Sq. Ft. |
| Number of Tables | 30 | 24 |
| Dimensions of Table Tops | | |
| Width | 44" | 60" |
| Depth | 36" | 36" |
| Width of Aisles in Drafting Room | 36" | 42" |

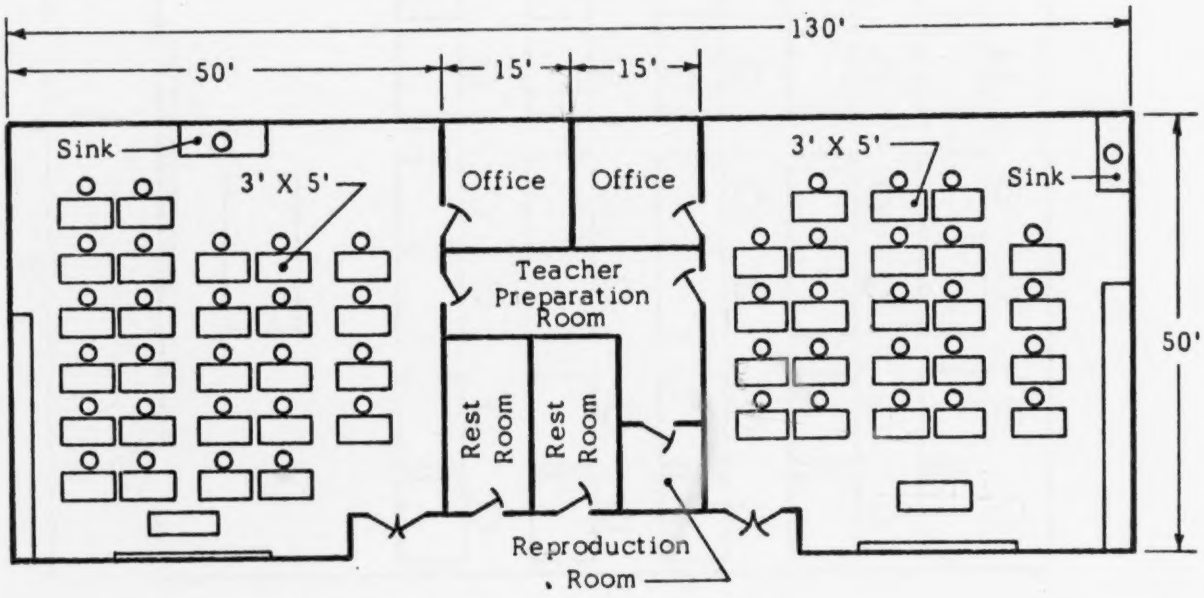


Cooke County Junior College

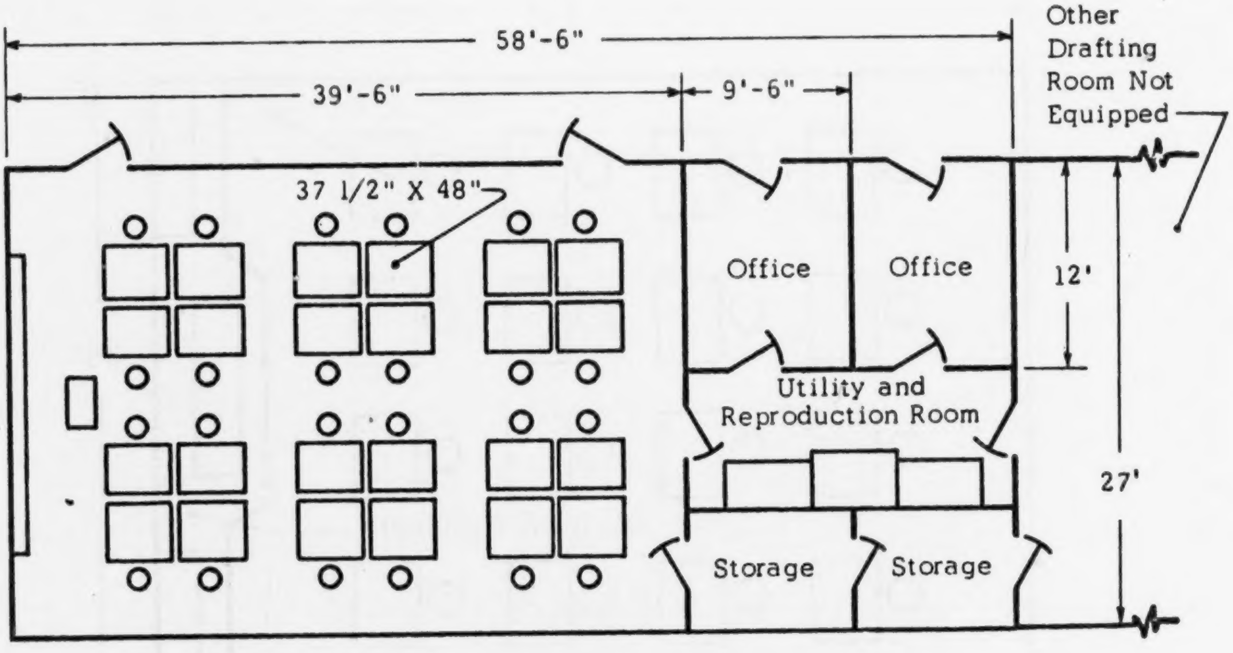

40'
36" X 44"
29'
Raised Platform

Kilgore College

Fig. 2--Typical drafting room layouts


130'
50'
15'
15'
Sink
3' X 5'
Office
Office
3' X 5'
Sink
Teacher Preparation Room
Rest Room
Rest Room
50'
Reproduction Room

Navarro Junior College


58'-6"
Other Drafting Room Not Equipped
39'-6"
9'-6"
37 1/2" X 48"
Office
Office
12'
Utility and Reproduction Room
27'
Storage
Storage

Henderson County Junior College

Fig. 2--Continued

Drafting Tables

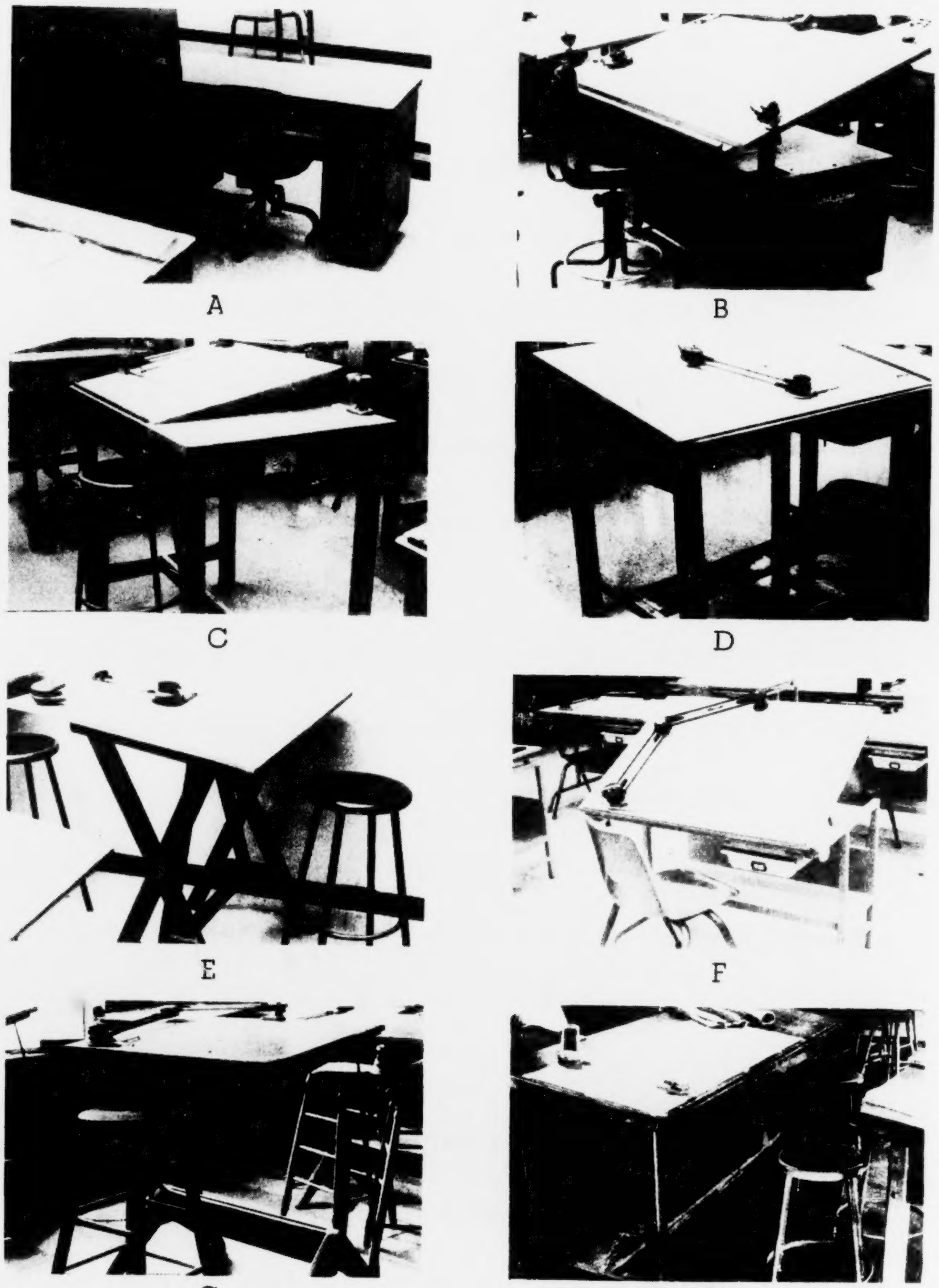
Plate I shows a sample of drafting tables that were being used in Texas junior colleges. In several colleges that had two drafting rooms -- one for beginning and one for advanced courses -- smaller tables such as those shown in Pictures C, E, and F of Plate I were usually in the room where beginning drafting courses were taught. The table shown in Picture C includes a reference area for books and drafting equipment. Chair-height tables, as shown in Picture F, were recommended by several instructors.

In advanced drafting courses, tables similar to Pictures A and B of Plate I were found. The table in Picture A was especially liked because of the large, accessible reference section and the ease with which the elevation and tilt angle of the table could be changed. These features of a work station tend to reduce fatigue and also give students experience on tables that are often found in industry.

For a facility that has only one drafting room, the table shown in Picture D would be adequate for both beginning and advanced courses. This drafting table is medium size but does not have a

## PLATE I

## DRAFTING TABLES



A B C D E F G H

reference section, height adjustments, or provisions for easily changed tilt angles.

Most drafting personnel recommended that electrical outlets be easily accesible to each drafting table, especially in advanced drafting rooms. Electrical outlets make it possible to use an electric eraser and to obtain additional illumination when needed.

Recommendation.--Based on data collected from drafting personnel, the following drafting tables are recommended:

| Drafting Rooms | Recommended Tables* |
|---|---|
| 1. Single drafting room | Picture D |
| 2. Two drafting rooms | |
| a. Beginning room | Pictures C and F |
| b. Advanced room | Pictures A and B |

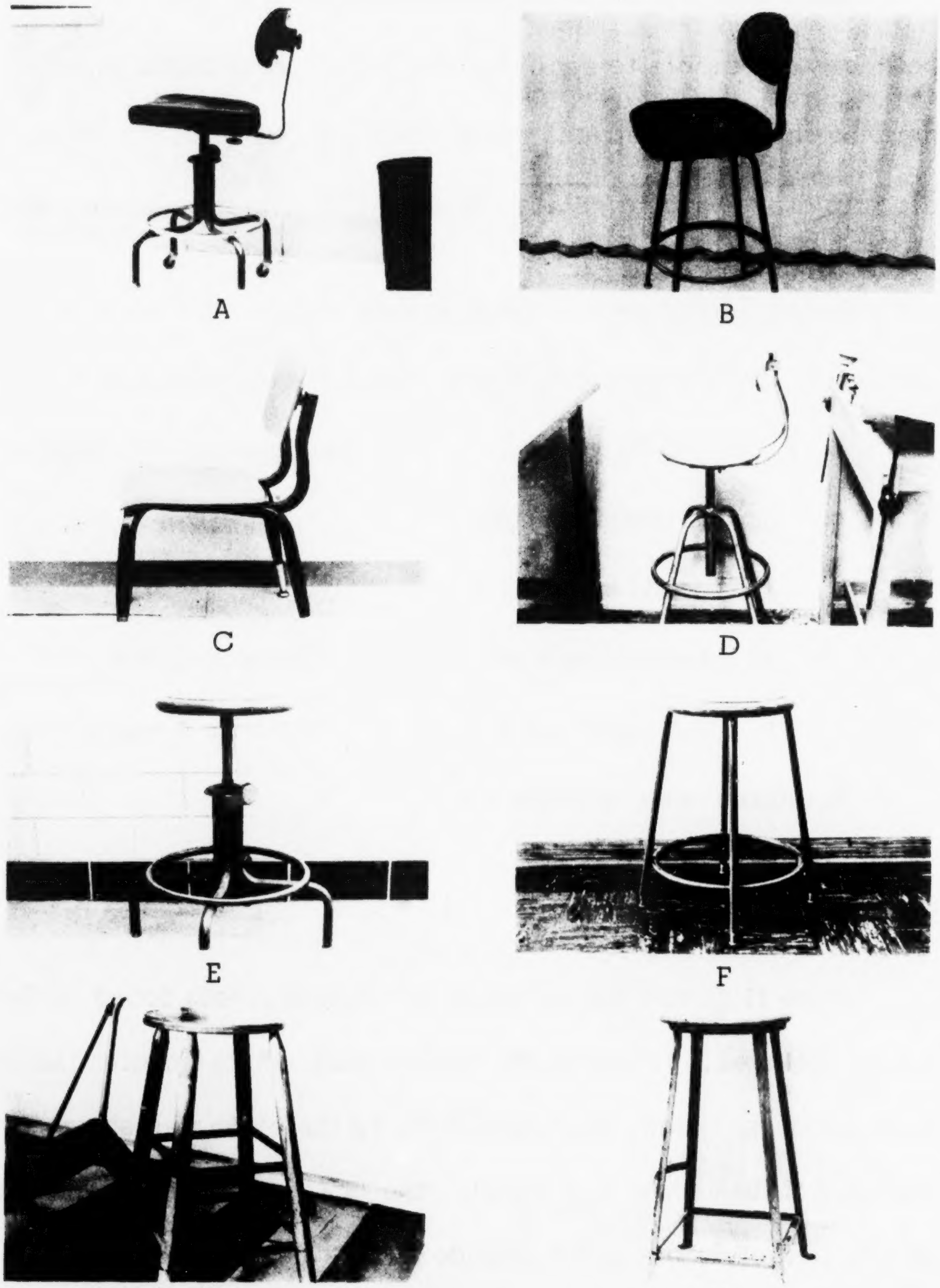
*Pictures refer to Plate I

## Chairs and Stools

Plate II shows examples of chairs and stools found in Texas junior colleges. In beginning laboratories where smaller tables were normally found, seating similar to the examples shown in Pictures C through H was found. The chair in Picture A and the stools in Pictures D and E provide height adjustments which help to accomodate students of various heights.

# PLATE II

# CHAIRS AND STOOLS



A B C D E F G H

In advanced drafting rooms, chairs similar to those in Pictures A and B of Plate II were found. The rollers on the chair in Picture A provide for ease of movement and tend to reduce classroom noise. Padded seats as shown in Pictures A and B aid in reducing fatigue.

Recommendation.--For a drafting room in which beginning courses are taught, the chairs in Pictures C and D or the stool in Picture E is recommended. For an advanced room, the chair in Picture A is suggested.

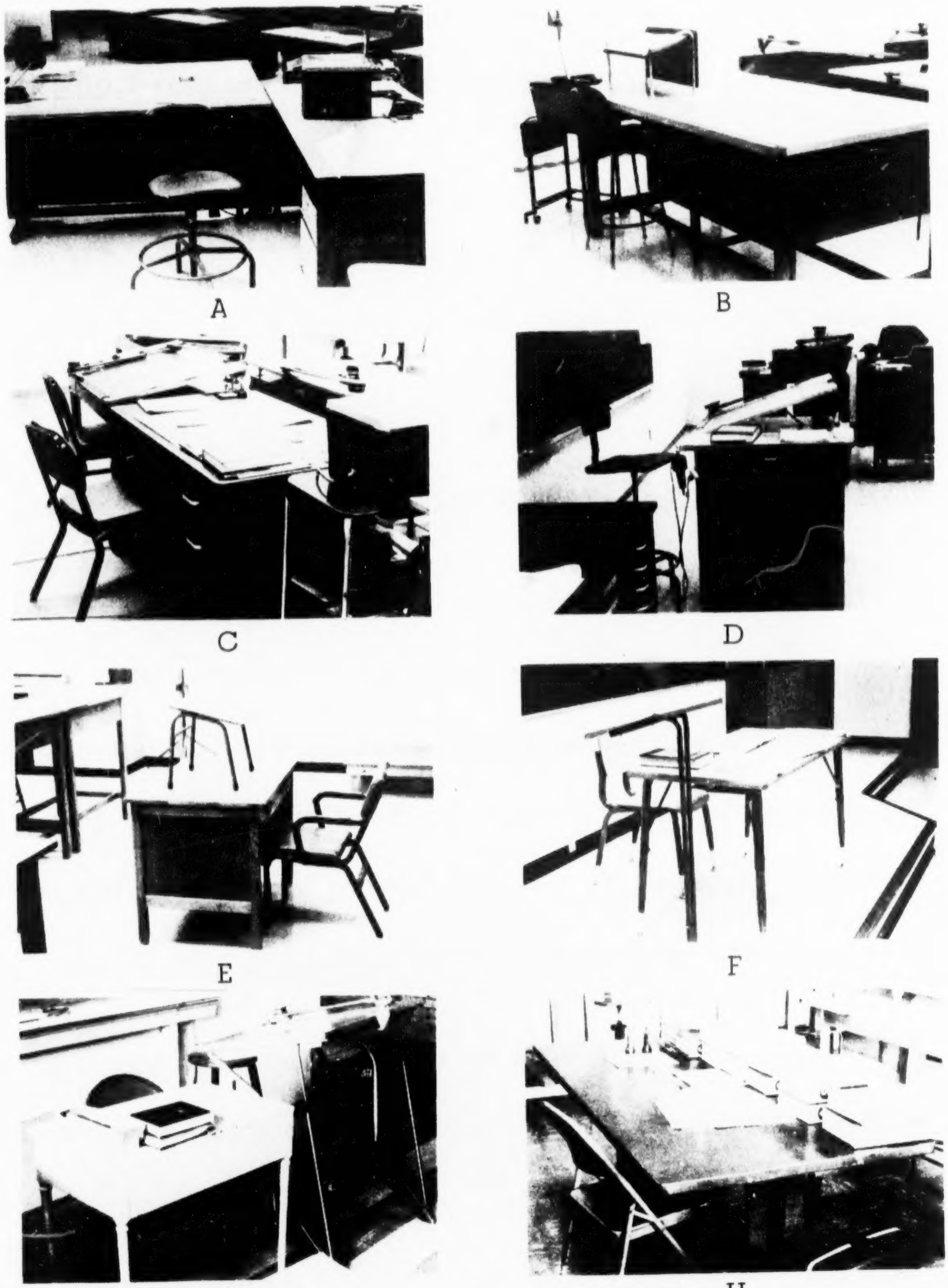
## Instructor's Desk in Drafting Room

An instructor has need for a desk or table within the drafting room to keep his teaching materials. As shown in Plate III instructors' drafting room furniture ranged from the latest L-shaped adjustable table and reference section (Picture A) to a small table or desk (Pictures E, F, and G). Several instructors used one of the drafting tables as their desk (Picture D).

Recommendation.--Based on the preferences indicated by drafting personnel, furniture similar to that shown in Pictures B, C, and D is recommended.

## PLATE III

## INSTRUCTORS' DESKS AND DRAFTING TABLES -- DRAFTING ROOMS



A B C D E F G H

## Drafting Equipment

Equipment needs will vary somewhat depending on the particular phases of drafting -- architecture, sturcture, technical illustration -- that are stressed. For example, compressed air outlets are needed to teach airbrush rendering in technical illustration courses. Likewise, some instructors who teach architectural drafting recommended that three or four drafting tables be equipped with parallel bars to provide students with an opportunity to gain additional drafting experience.

Recommendation.--Based on the recommendations of drafting personnel, a list of equipment for each drafting room is presented (Table 5 ). If airbrush is to be taught, approximately four air outlets are recommended. For advanced architectural drafting, four to six parallel bars are suggested to provide training commensurate with architectural firms.

## TABLE 5

## RECOMMENDED EQUIPMENT FOR EACH DRAFTING ROOM

| Equipment | Number Rec. |
|---|---|
| Drafting Machines (table) | 1 (per table) |
| Lead Pointers | 5 |
| Lettering Sets | |
| Leroy | 2 |
| Doric | 2 |
| Wrico | 1 |
| Pencil Sharpener (Draftsman's) | 1 |
| Pen Sets | |
| Koh-I-Noor | 2 |
| Leroy | 2 |
| Templates | |
| Ellipse | 5 (sets) |
| Circle | 4 (sets) |
| Electrical | 3 |
| House Plan | 3 |
| Hex Bolts & Nuts | 3 |
| Machine | 3 |
| Plumbing | 2 |
| Alphabet | 2 |
| Window | 2 |
| Geometric | 1 |
| Transistor | 1 |
| Furniture | 1 |

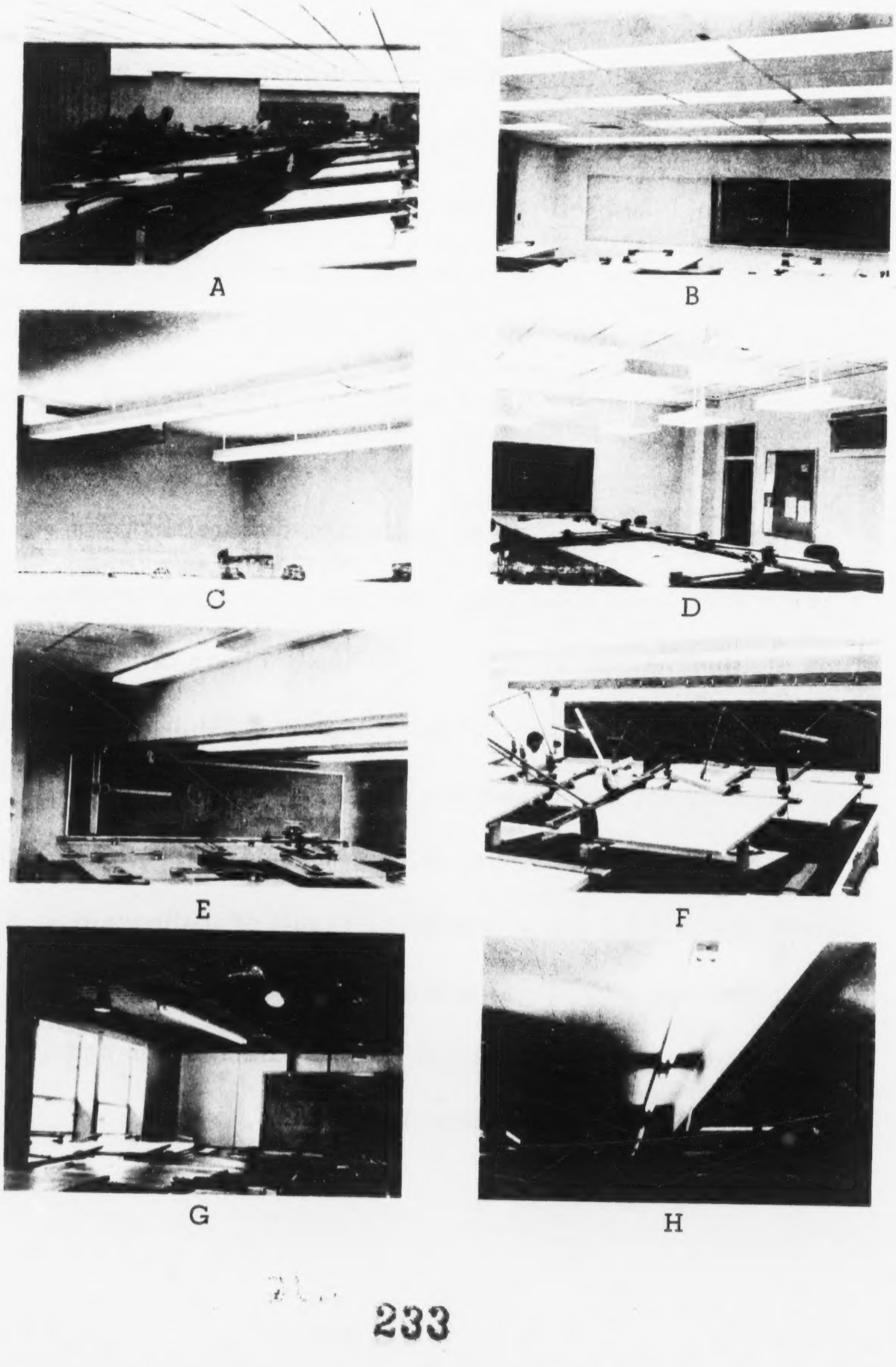
## Illumination

Planning for the illumination of drafting facilities should be carefully considered. It is strongly recommended that a qualified person be included in the planning phases of a drafting facility to insure high quality, shadow-free illumination. Although footcandle readings alone will not insure adequate illumination, two hundred footcandles are recommended by IES Lighting Handbook (Kaufman, 1966).

Plate IV shows examples of illuminated drafting rooms. Picture A of Plate IV shows a drafting room that is well illuminated. This type of illumination provides ample shadow-free light. Pictures B, C, and D are examples of acceptable illumination if drafting tables are correctly located within the room. Illumination shown in Pictures E, F, G, and H are not recommended. The table lamps shown in Picture F are primarily the result of inadequate architectural planning. The illumination shown in Picture G is very inadequate because of too little interior illumination and an over abundance of exterior, uncontrollable light.

## PLATE IV

## DRAFTING ROOM ILLUMINATION



A B

C D

E F

G H

*Recommendation*.--Illumination similar to that shown in Picture A of Plate IV is highly recommended. Illumination illustrated in Pictures B, C, and D is adequate.

## Conveniences

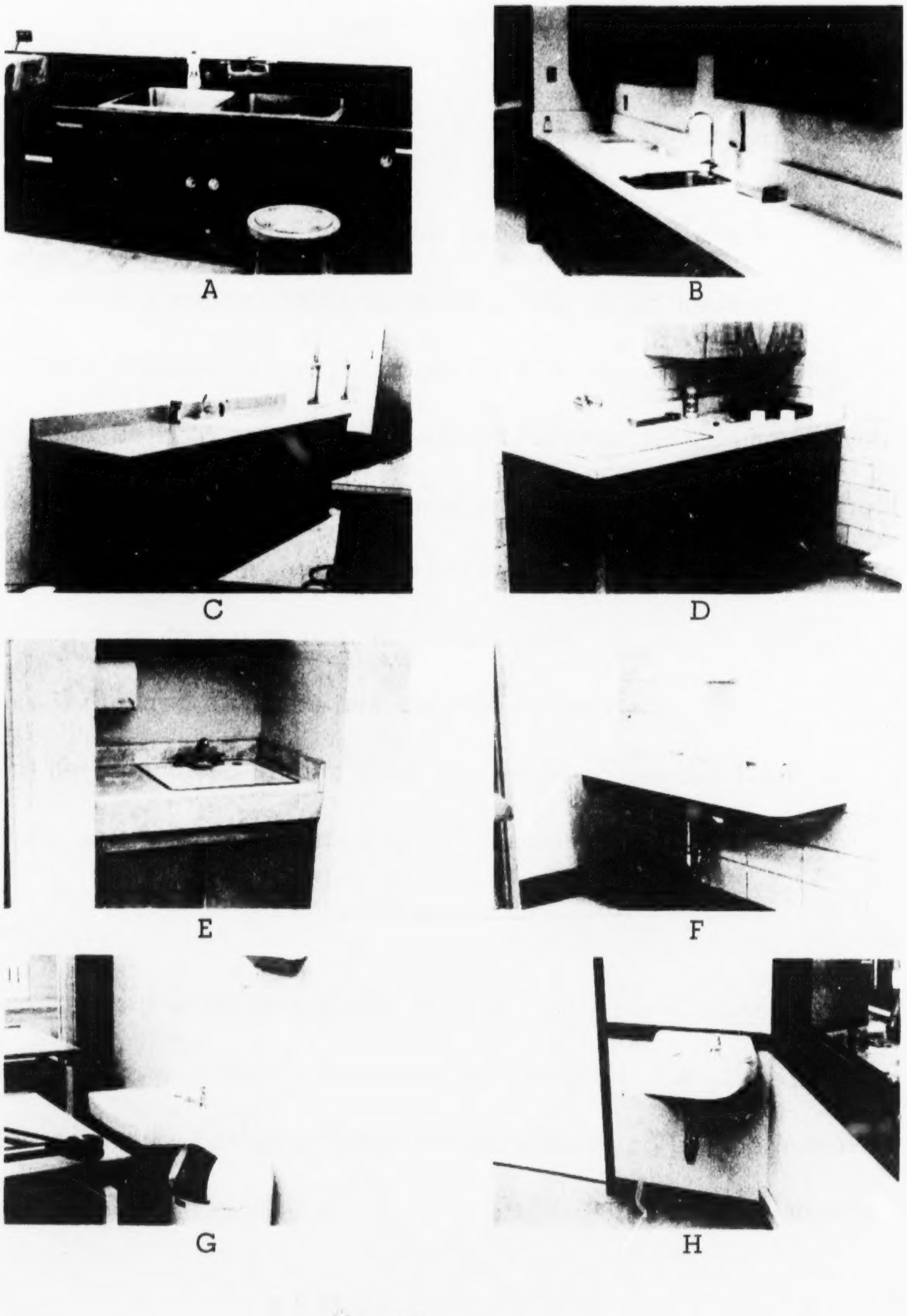
A wash basin is needed in a drafting room so that students can keep their hands and equipment clean. Plate V shows examples of wash basins available in the colleges. Pictures A and B are two examples of large wash basins which are located in storage or reproduction rooms. Pictures C through H are basins located within drafting rooms. The basins shown in F, G, and H are adequate; however, the appearance and utility of each could be improved by constructing drawers and cabinets beneath them.

Rest rooms for men and women should be located on the same floor as the drafting room. For convenience, the rooms should be within sixty feet of the drafting laboratory.

*Recommendation*.--A wash basin similar to those shown in Pictures C, D, and E are recommended. Rest rooms for men and women should be located on the same floor and within sixty feet of the drafting room.

## PLATE V

## WASH BASINS



### Student Storage

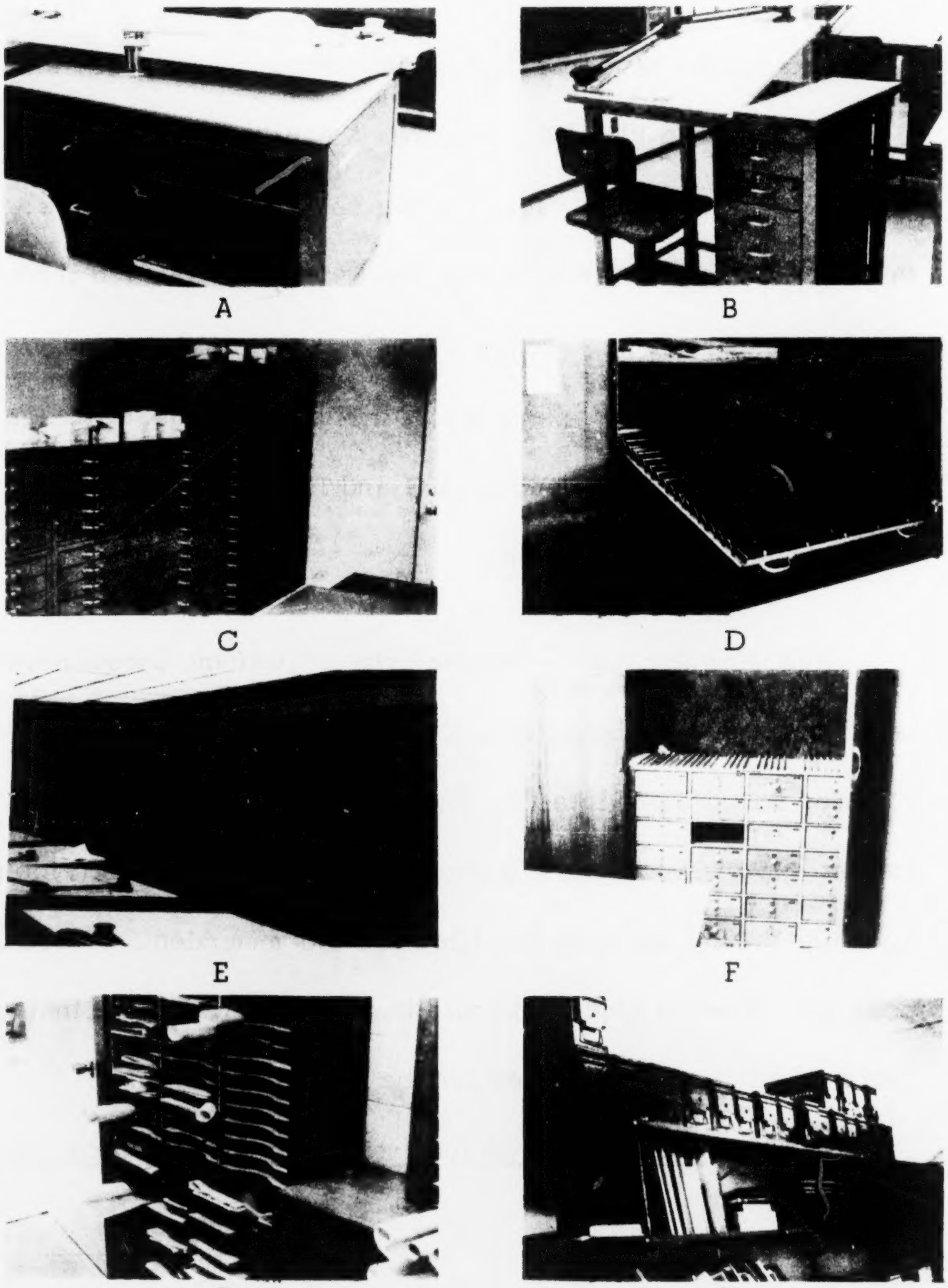
Storage for students can include lockers, drawers, and flat files as shown in Plate VI. Pictures A and B of Plate VI are examples of student storage that are part of drafting tables. Picture C displays flat files that were centrally located for students. The storage cabinet in Picture D is for maps and large drawings. Pictures E and F show examples of individual student storage that was centrally located. Pictures G and H are examples of relatively inexpensive student storage.

Recommendation.-- The majority of drafting personnel recommended storage for beginning courses similar to that shown in Pictures B and E of Plate VI. For advanced courses storage similar to that shown in Picture A is recommended. A map file (Picture D) and five-drawer units of flat files are recommended. Where possible, student storage should be provided with combination locks that have a master key for the instructor.

TURN TO FORM II-E-2A for estimating drafting room facilities.

PLATE VI

STUDENT STORAGE



A B C D E F G H

FORM II-E-2A

## FACILITIES FOR ADVANCED DRAFTING ROOM
## (18-24 STUDENT CAPACITY)

EXAMPLE

| Item | Recommended Quantity | Estimated Quantity Needed | | Unit Cost | | Total Cost |
|---|---|---|---|---|---|---|
| A. Minimum requirements | | | | (Range) | | (Range) |
| Drafting tables | 18-24 | 15 | X | 315 to 560 | = | 5,625 to 8,400 |
| Drafting chairs | 18-24 | 15 | X | 35 to 60 | = | 525 to 900 |
| Drafting machines, table | 1 per table | 15 | X | 50 to 200 | = | 750 to 3,000 |
| Drafting machines, chalkboard | 1 | — | X | — to — | = | — to — |
| Instructor's desk, drafting room | 1 | 1 | X | 100 to 260 | = | 100 to 260 |
| Instructor's chair, drafting room | 1 | 1 | X | 40 to 120 | = | 40 to 120 |
| Wash basin with cabinets | 1 | 1 | X | 250 to 950 | = | 250 to 950 |
| | | Minimum Requirements Sub-total | | | | 7,290 to 13,630 (1) |
| B. Additional Facilities | | | | | | |
| Bulletin boards | 2 | 1 | X | 15 to 35 | = | 15 to 35 |
| Display case, drafting room | 2 | 1 | X | 50 to 150 | = | 50 to 150 |
| File cabinet | 1 | 1 | X | 50 to 150 | = | 50 to 150 |
| Light table | 1 | — | X | — to — | = | — to — |
| Map storage cabinet | 1 | — | X | — to — | = | — to — |
| Overhead projector | 1 | 1 | X | 150 to 320 | = | 150 to 320 |
| Paper cutter | 1 | — | X | — to — | = | — to — |
| Projection screen, permanently mounted | 1 | 1 | X | 40 to 65 | = | 40 to 65 |
| | | Additional Facilities Sub-total | | | | 305 to 720 (2) |

FORM II-E-2A (Continued)

### FACILITIES FOR ADVANCED DRAFTING ROOM--Continued

| Item | Recommended Quantity | Estimated Quantity Needed | | Unit Cost (Range) | | Total Cost (Range) |
|---|---|---|---|---|---|---|
| C. Small equipment items | | | | | | |
| Lead pointers | 5 | 3 | X | 2 to 4 | = | 6 to 12 |
| Lettering sets | 5 | 2 | X | 35 to 120 | = | 70 to 240 |
| Pencil sharpeners, draftsman | 1 | 1 | X | 4 to 5 | = | 4 to 5 |
| Pencil sharpeners, regular | 1 | 1 | X | 4 to 5 | = | 4 to 5 |
| Technical fountain pen sets (3-7 pens) | 4 | 2 | X | 8 to 18.50 | = | 16 to 37 |
| Template, assortment | 24 | 10 | X | 50 to 100 | = | 500 to 1,000 |
| | | Small Equipment Sub-total | | | | 600 to 1,299 (3) |
| | ADVANCED DRAFTING ROOM FACILITIES TOTAL | | | | | 8,195 to 15,649 (4) |

TURN TO FORM II-E-2B, page 217, to estimate beginning drafting room facilities.

FORM II-E-2B

## FACILITIES FOR BEGINNING DRAFTING ROOM
## (20-30 STUDENT CAPACITY)

EXAMPLE

| Item | Recommended Quantity | Estimated Quantity Needed |  | Unit Cost |  | Total Cost |
|---|---|---|---|---|---|---|
| A. Minimum requirements |  |  |  | (Range) |  | (Range) |
| Drafting tables | 20-30 | 20 | X | 60 to 85 | = | 1,200 to 1,700 |
| Drafting chairs | 20-30 | 20 | X | 15 to 25 | = | 300 to 500 |
| Drafting machines, table | 1 per table | 20 | X | 50 to 200 | = | 1,000 to 4,000 |
| Drafting machines, chalkboard | 1 | — | X | — to — | = | — to — |
| Instructor's desk, drafting room | 1 | 1 | X | 100 to 260 | = | 100 to 260 |
| Instructor's chair, drafting room | 1 | 1 | X | 40 to 120 | = | 40 to 120 |
| Wash basin with cabinets | 1 | 1 | X | 250 to 950 | = | 250 to 950 |
|  |  | Minimum Requirements Sub-total |  |  |  | 2890 to 7,530 (1) |
| B. Additional Facilities |  |  |  |  |  |  |
| Bulletin boards | 2 | 1 | X | 15 to 35 | = | 15 to 35 |
| Display case, drafting room | 2 | 1 | X | 50 to 150 | = | 50 to 150 |
| File cabinet | 1 | 1 | X | 50 to 150 | = | 50 to 150 |
| Light table | 1 | — | X | — to — | = | — to — |
| Map storage cabinet | 1 | — | X | — to — | = | — to — |
| Overhead projector | 1 | 1 | X | 150 to 320 | = | 150 to 320 |
| Paper cutter | 1 | — | X | — to — | = | — to — |
| Projection screen, permanently mounted | 1 | 1 | X | 40 to 65 | = | 40 to 65 |
|  |  | Additional Facilities Sub-total |  |  |  | 305 to 720 (2) |

FORM II-E-2B (Continued)

FACILITIES FOR BEGINNING DRAFTING ROOM--Continued

| Item | Recommended Quantity | Estimated Quantity Needed | | Unit Cost | | Total Cost |
|---|---|---|---|---|---|---|
| | | | | (Range) | | (Range) |
| C. Small equipment items | | | | | | |
| Lead pointers | 5 | 3 | X | 2 to 4 | = | 6 to 12 |
| Lettering sets | 5 | 2 | X | 35 to 120 | = | 70 to 240 |
| Pencil sharpeners, draftsman | 1 | 1 | X | 4 to 5 | = | 4 to 5 |
| Pencil sharpeners, regular | 1 | 1 | X | 4 to 5 | = | 4 to 5 |
| Technical fountain pen sets (3-7 pens) | 4 | 2 | X | 8 to 18.50 | = | 16 to 37 |
| Template, assortment | 30 | 15 | X | 50 to 100 | = | 750 to 1,500 |
| | | Small Equipment Sub-total | | | | 850 to 1,799 (3) |
| | BEGINNING DRAFTING ROOM FACILITIES TOTAL (Sum of lines (1), (2), and (3) ) | | | | | 4,045 to 10,049 (4) |

TURN TO PAGE 219 for a discussion of instructors' offices.

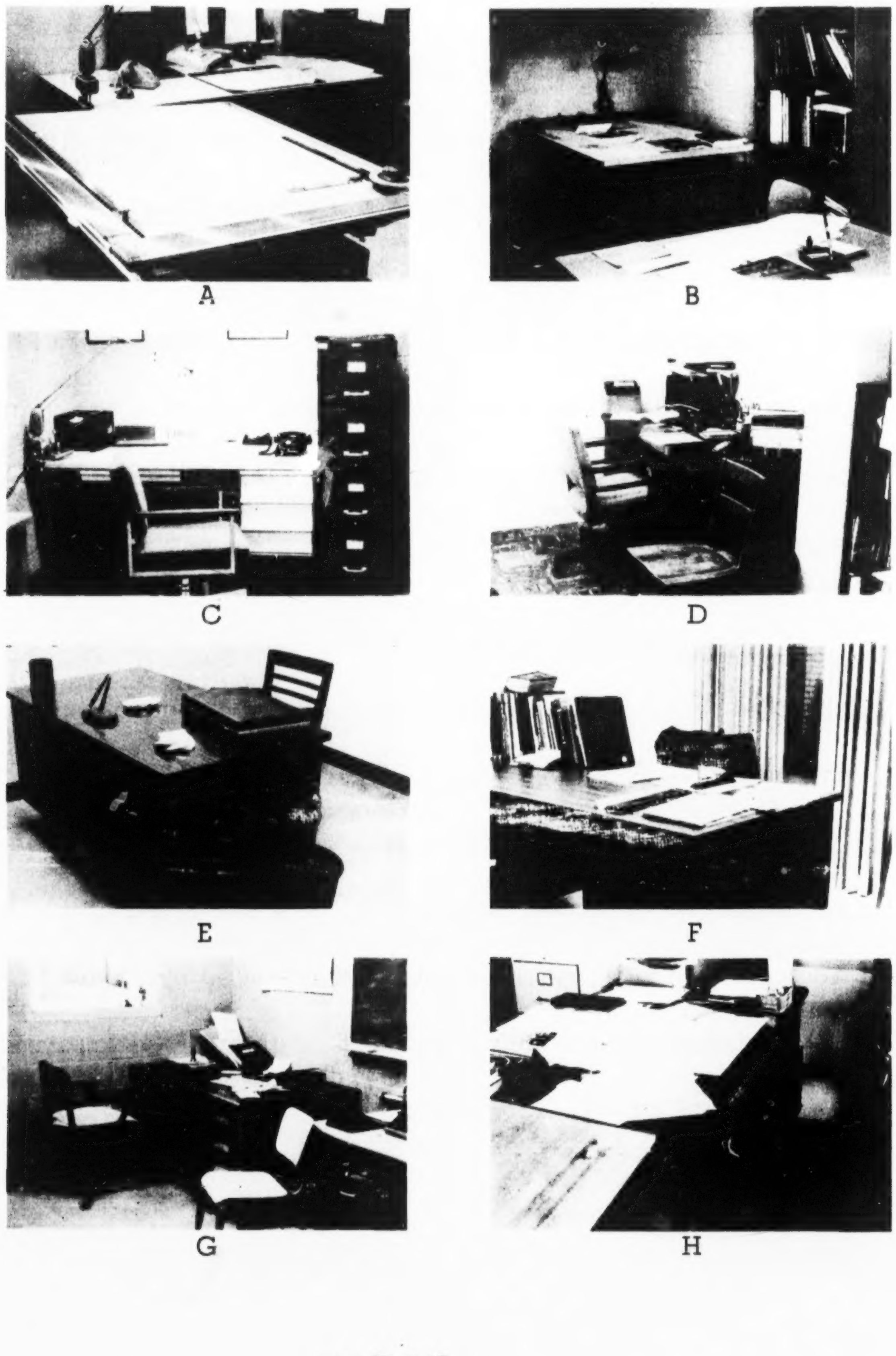
Instructor's Office

The type of office provided for instructors is an important aspect of educational planning. Ninety percent of the drafting personnel indicated a preference for a private office. Approximately two-thirds of the instructors suggested that an office be located near the drafting room. Examples of offices are shown in Plate VII. A majority of the instructors recommended a drafting table and a desk in an office. Pictures A and B are examples of offices that include a drafting table.

Recommendation.--The preferences of drafting personnel suggested that an office have a desk similar to those shown in Pictures A, C, E, and F and a drafting table similar to those shown in Pictures A and B. In addition to a desk and drafting table, most instructors recommended a telephone and typewriter. A calculator or adding machine was recommended by several people as a needed office machine. Table 6 indicates the recommended dimensions of an office for one person.

## PLATE VII

## DESKS AND DRAFTING TABLES -- INSTRUCTORS' OFFICES



A B C D E F G H

## TABLE 6

## OFFICE DIMENSIONS

| | Dimensions |
|---|---|
| Minimum | 8' X 10' |
| Adequate | 9' X 10' |
| Optimum | 10' X 12' |

TURN TO FORM II-E-3, page 222 to estimate office facilities.

FORM II-E-3

## FACILITIES FOR EACH OFFICE

EXAMPLE

| Item | Recommended Quantity | Estimated Quantity Needed | | Unit Cost | | Total Cost | |
|---|---|---|---|---|---|---|---|
| Office Facilities | | | | (Range) | | (Range) | |
| A. Minimum recommendations | | | | | | | |
| Desk | 1 | 1 | X | 100 to 260 | = | 100 to 260 | |
| Chair, swivel | 1 | 1 | X | 40 to 120 | = | 40 to 120 | |
| Chair, regular | 2 | 2 | X | 20 to 95 | = | 40 to 190 | |
| | Minimum Recommendations Sub-Total | | | | | 180 to 570 | (1) |
| B. Additional facilities | | | | | | | |
| Adding machine | 1 | — | X | — to — | = | — to — | |
| Drafting table | 1 | 1 | X | 375 to 560 | = | 375 to 560 | |
| Drafting machine | 1 | 1 | X | 50 to 200 | = | 50 to 200 | |
| Drafting chair | 1 | 1 | X | 35 to 60 | = | 35 to 60 | |
| Flat files (5-drawer unit) | 1 | 1 | X | 110 to 230 | = | 110 to 230 | |
| File cabinet | 1 | 1 | X | 50 to 150 | = | 50 to 150 | |
| Telephone | 1 | — | X | — to — | = | — to — | |
| Typewriter | 1 | — | X | — to — | = | — to — | |
| | Additional Facilities Sub-Total | | | | | 620 to 1,200 | (2) |
| | OFFICE FACILITIES TOTAL | | | | | 800 to 1,770 | (3) |

TURN TO PAGE 223 for a discussion of departmental storage, and utility-teacher preparation facilities, including reproduction equipment.

Department Storage

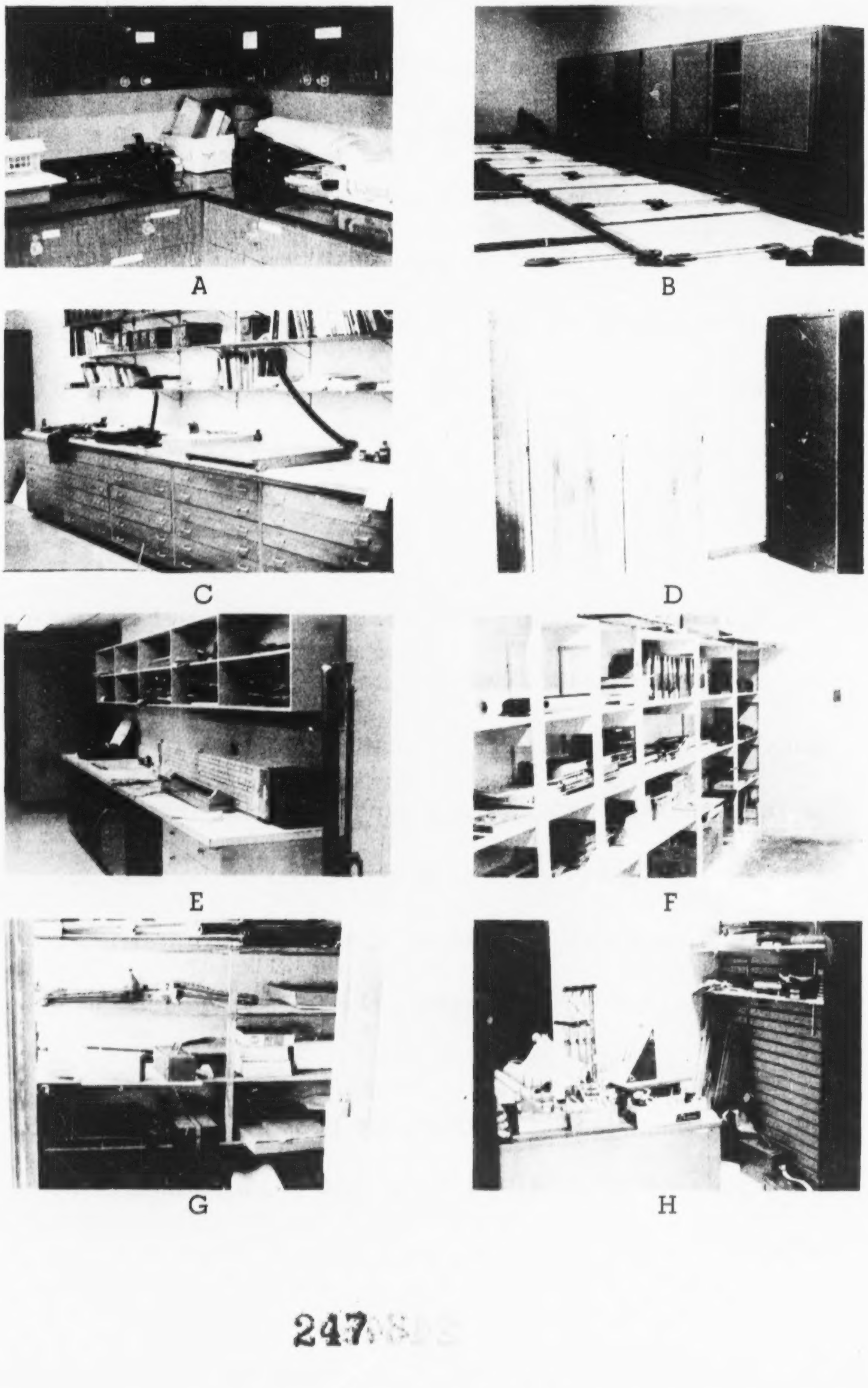
Plate VIII shows examples of departmental storage. Pictures B and E illustrate storage located within the drafting room, whereas the other pictures are examples of storage located in a separate room. Storage facilities with counter top work space are shown in Pictures A and C. Open storage as shown in Pictures F and G is quite commonly found in the colleges; this type of storage, however, requires frequent cleaning and straightening or it becomes unsightly. Picture H is an example of a storage room that lacks cabinets and drawers.

Recommendation.--Book case shelving, flat file cabinets, file cabinets, metal and wooden cabinets, and closets or separate rooms are examples of storage that are common to drafting facilities. The recommended storage for a single drafting room and instructor, based on the data collected, is presented in the next several tables. Storage will need to be increased as a drafting program enlarges, but for initial planning the following recommendations should be adequate.

The linear feet of shelving for books and magazines for an instructor's office, drafting room, and department are shown in Table 7.

# PLATE VIII

## DEPARTMENTAL STORAGE



A B C D E F G H

TABLE 7

LINEAR FEET OF SHELVING

| | Minimum (linear feet) | Adequate (linear feet) | Optimum (linear feet) |
|---|---|---|---|
| Office | 15 | 20 | 25 |
| Drafting Room | 30 | 45 | 75 |
| Department | 25 | 35 | 60 |

Approximately one-third of the respondents recommended flat file cabinets for office and departmental storage. Limited space in some offices and departments resulted in a low percentage of respondents recommending flat file storage. Therefore, the recommendations shown in Table 8 are based primarily on personal visits with drafting personnel who had adequate office and departmental storage.

File cabinets to keep information such as student records and correspondence are needed. Table 9 presents the minimum, adequate, and optimum number of cabinets for a drafting facility. It is recommended that file cabinets have either four or five drawers and that at least one cabinet be large enough to store legal-size materials.

## TABLE 8

## NUMBER OF FLAT FILE CABINET UNITS
(49 5/16" X 38 1/2" X 15 3/8")

| | Minimum | Adequate | Optimum |
|---|---|---|---|
| Office | 1 | 1 | 2 |
| Department | 1 | 2 | 3 |

## TABLE 9

## NUMBER OF FILE CABINETS

| | Minimum | Adequate | Optimum |
|---|---|---|---|
| Office | 1 | 1 | 2 |
| Drafting Room | 1 | 1 | 2 |
| Department | 1 | 2 | 2 |

Large metal or wooden cabinets are needed to store such materials as templates, lettering pens, and paper. The recommended dimensions of a large metal or wooden cabinet are 48" wide by 24" deep by 72" high. Table 10 gives the number of cabinets recommended for an office, a drafting room, and a department.

TABLE 10

NUMBER OF LARGE METAL OR WOODEN CABINETS

| | Minimum | Adequate | Optimum |
|---|---|---|---|
| Office | 1 | 1 | 1 |
| Drafting | 1 | 1 | 2 |
| Department | 1 | 2 | 2 |

A small closet (2'by 4') is recommended for each instructor to keep his personal belongings. A large, separate room for teacher preparations is recommended. Table 11 shows the recommended square feet for a preparation room.

TABLE 11

RECOMMENDED SIZE OF TEACHER PREPARATION ROOM

| | Minimum (Square Feet) | Adequate (Square Feet) | Optimum (Square Feet) |
|---|---|---|---|
| Preparation Room | 150 | 200 | 250 |

Library, Display Case and Bulletin Board

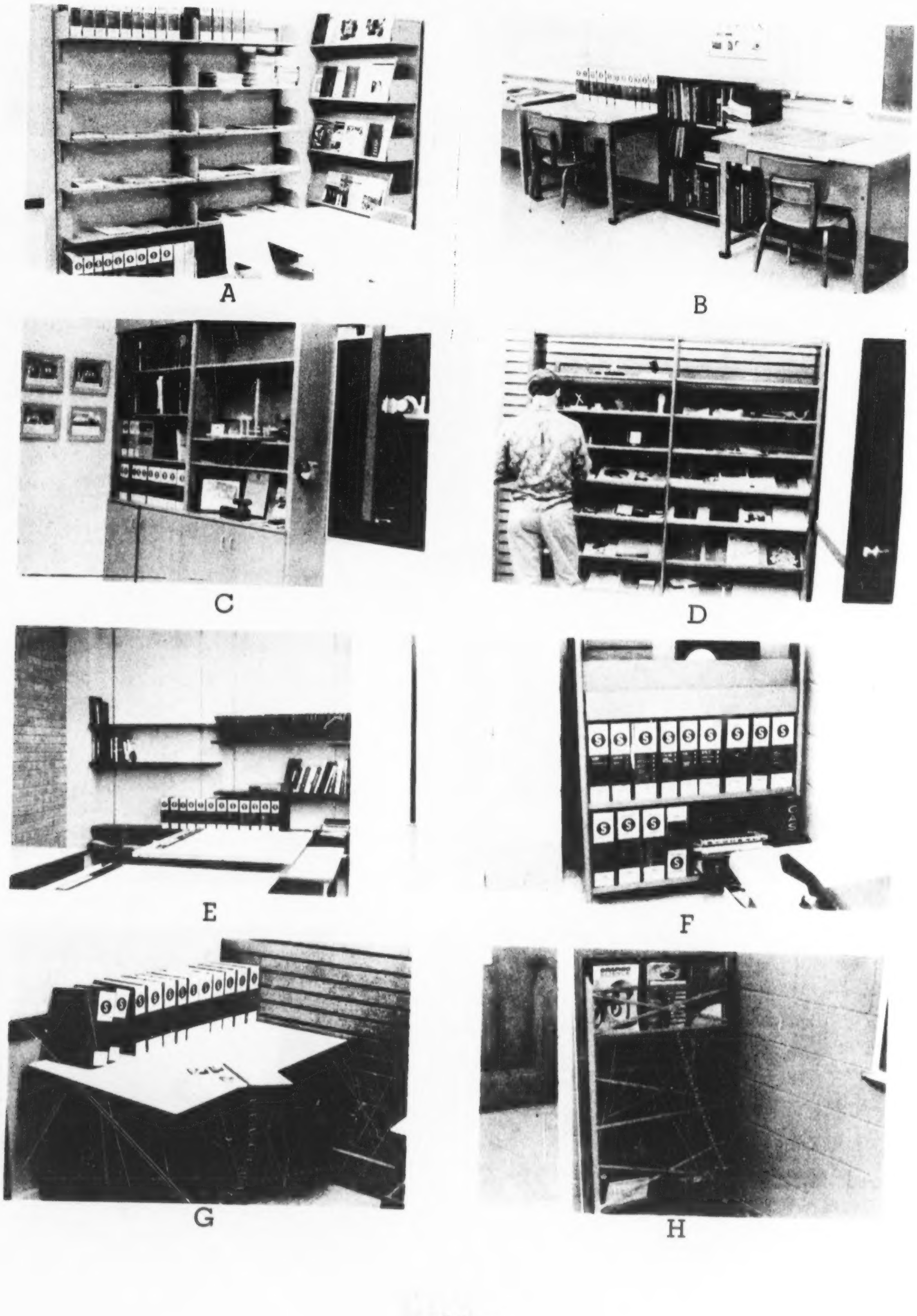
Drafting facilities should have provisions within the drafting room or nearby to store reference books, magazines, journals, and catalogs. Plate IX shows some examples of drafting facilities that have provisions for storing reference materials. Picture A illustrates a drafting library that is centrally located to accomodate two drafting rooms; whereas, the other reference facilities illustrated are located within the drafting room. The reference area displayed in Picture B is located near the back of the drafting room.

Examples of display cases and bulletin boards are illustrated in Plate X. The display case shown in Picture A is located in the hall near the drafting room and the cases shown in C, E, and G are located within the drafting room.

Recommendation.-- A display case located within the drafting room such as those shown in Pictures E and G is recommended. In addition, a display case that is located in a hall or corridor and shared by other disciplines, is also recommended. The recommended dimensions of a display case located within the drafting room are 6' wide by 18" deep by 4' high. A large case is suggested for a

## PLATE IX

## MAGAZINE AND REFERENCE MATERIAL STORAGE



A B

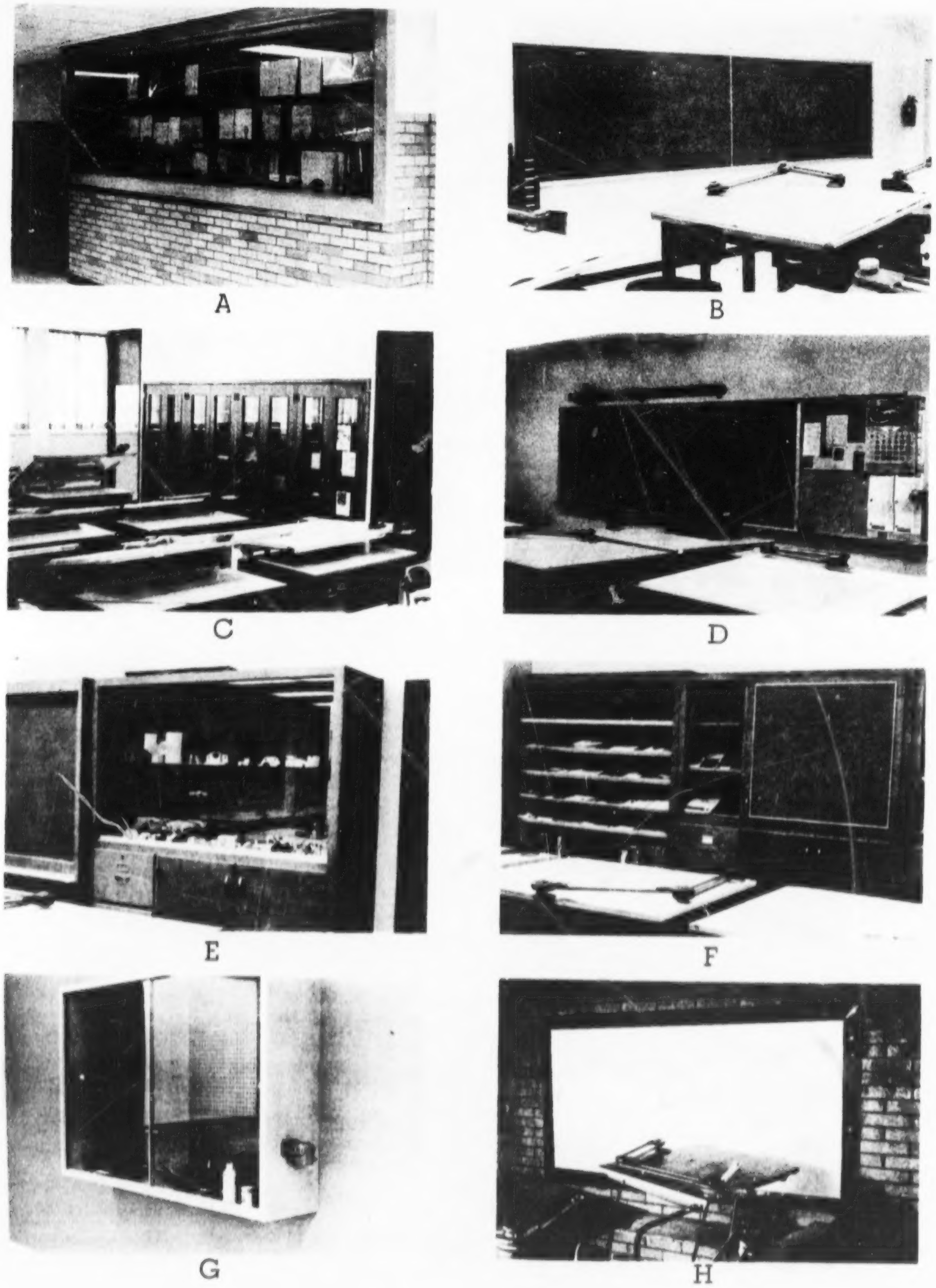
C D

E F

G H

## PLATE X

## DISPLAY CASES AND BULLETIN BOARDS



A B C D E F G H

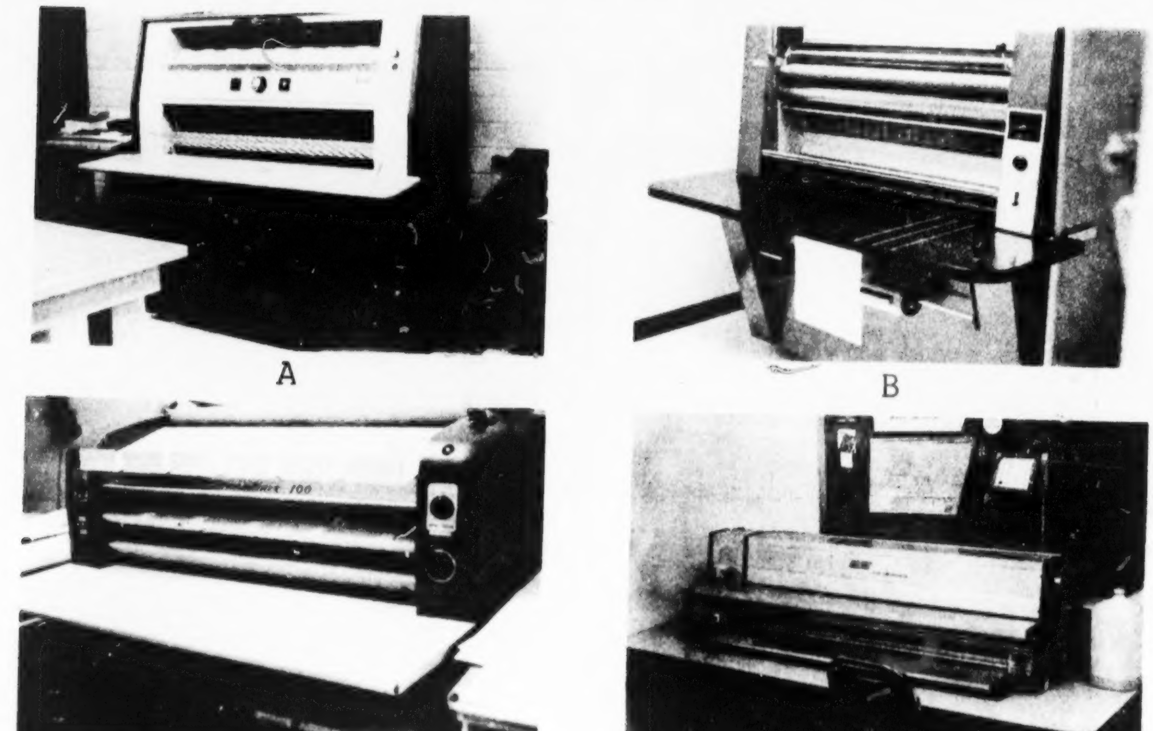
hall or corridor. A bulletin board located at the end of the chalkboard, as shown in Picture D, and another board (4' by 8') located elsewhere in the drafting room are recommended for drafting facilities. Plate X shows examples of various sizes and locations of bulletin boards. For example, Picture B shows a large board and Pictures D, F, and H are smaller bulletin boards. The bulletin board shown in Picture D is located at the front of the room and Pictures B, F, and H are boards located along the side of the room.

## Reproduction Equipment

A machine that will provide good reproductions of drawings is needed to adequately train drafting technologists. Plate XI shows several examples of reproduction equipment found at various colleges. The machines shown in Pictures A and B are large commercial machines; whereas, the other machines shown in Plate XI are small and less expensive machines. Reproduction equipment should be located in a room joining the drafting room because of ammonia fumes and noise. The complete specifications, especially the overall dimensions of a reproduction machine,

PLATE XI

REPRODUCTION EQUIPMENT



A B C D E F G H

should be available in the planning phases of a building to allow for adequate space and for spot ventilation.

Recommendation.--The majority of the drafting personnel recommended a reproduction machine similar to those shown in Pictures A and B of Plate XI. Several drafting people recommended a microfilming camera and reader.

TURN TO FORM II-E-4 for estimating utility-teacher preparation facilities.

FORM II-E-4

## FACILITIES FOR A UTILITY-TEACHER PREPARATION ROOM

EXAMPLE

| Item | Recommended Quantity | Estimated Quantity Needed | | Unit Cost | | Total Cost |
|---|---|---|---|---|---|---|
| Utility-Preparation Room | | | | (Range) | | (Range) |
| Built-in cabinets | | { — | X | — to — | = | — to — |
| Counters | | 1 | X | 75 to 700 | = | 75 to 700 |
| Flat files | 2 | 2 | X | 110 to 220 | = | 220 to 460 |
| File cabinets | 2 | 2 | X | 70 to 150 | = | 140 to 300 |
| Metal cabinet | 2 | 2 | X | 400 to 600 | = | 800 to 1200 |
| Paper cutter, table model | 1 | 1 | X | 30 to 65 | = | 30 to 65 |
| Reproduction machine | 1 | 1 | X | 1,500 to 2,500 | = | 1,500 to 2,500 |
| Sink | 1 | 1 | X | 250 to 950 | = | 250 to 950 |
| UTILITY-TEACHER PREPARATION TOTAL | | | | | | 3,015 to 6,225 (1) |

TURN TO PAGE 235 for a discussion of visual-aid equipment.

## Visual-Aid Equipment

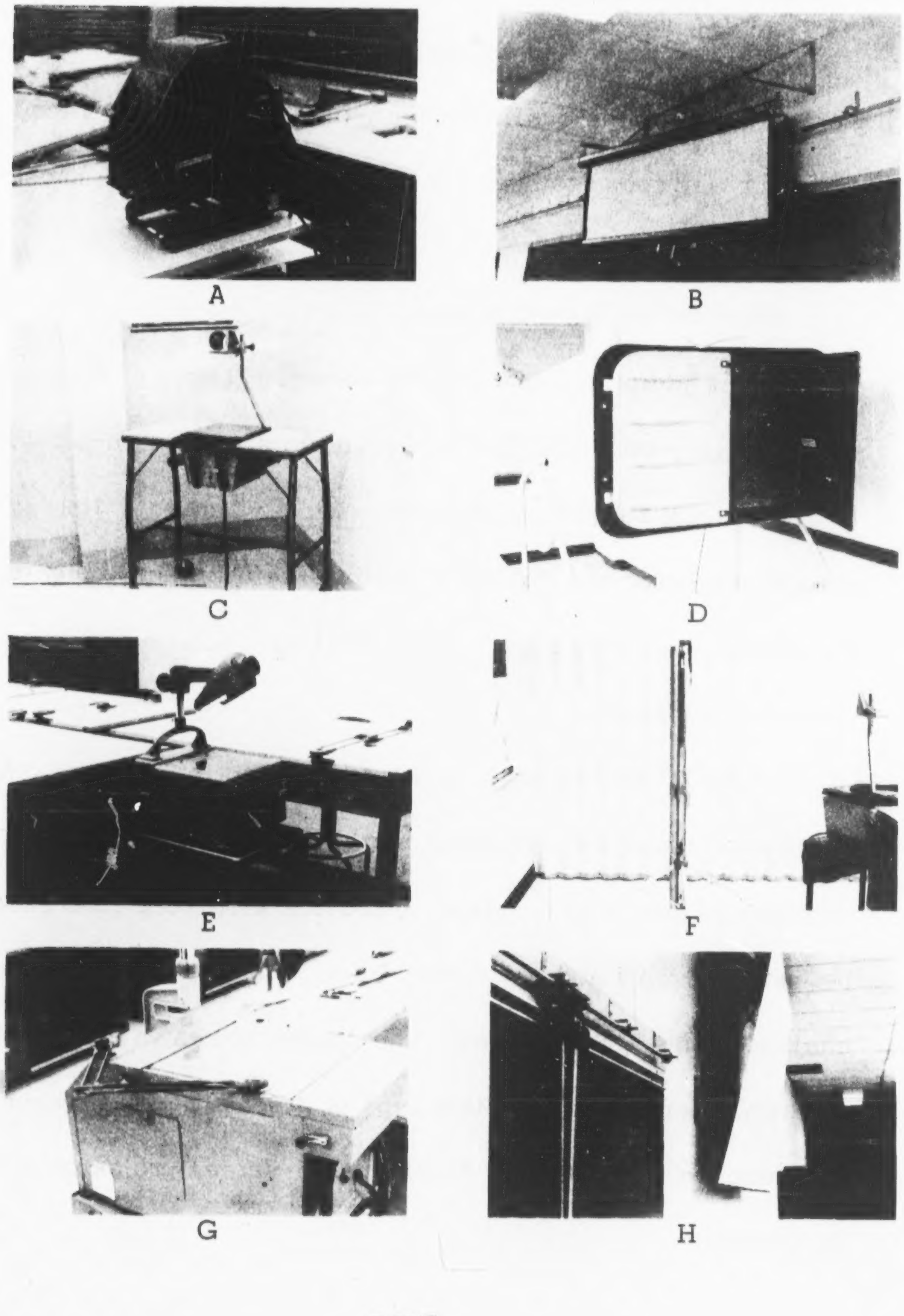
Drafting personnel should have access to visual-aid equipment to enhance the quality of their teaching. The overhead projector was found to be the most common visual-aid machine in the drafting room.

Plate XII shows examples of visual-aid equipment found in the various junior college drafting rooms. Picture C shows an overhead projector mounted on a portable stand which provides adequate room for placing transparencies. Picture A displays an opaque projector and Picture E exhibits an overhead projector. Picture G illustrates a very small drafting machine mounted to an overhead projector.

Plate XII shows several types of projection screens. A permanently mounted screen is shown in Picture B. Care must be taken in mounting a screen to provide sufficient clearance between the wall and the screen to allow enough room for the chalkboard drafting machine. The screen shown in Picture H is somewhat permanent, but this type of screen requires frequent maintenance and upkeep. A behind-the-screen projector is shown in Picture D.

PLATE XII

VISUAL-AID EQUIPMENT AND PROJECTION SCREENS



A B C D E F G H

Recommendation.-- According to Texas junior college drafting personnel, the equipment listed in Table 12 should be easily accessible to the instructor. It was generally agreed by the draftsmen that each drafting room should be equipped with an overhead projector. A permanently mounted projection screen similar to the one shown in Picture B is recommended.

TABLE 12

VISUAL-AID EQUIPMENT

| Recommended Equipment |
|---|
| 16 mm Projector |
| 8 mm Projector |
| Filmstrip Projector |
| Slide Projector |
| Opaque Projector |
| Tape Recorder |
| 35 mm Camera |
| 35 mm Copy Stand |
| Ditto Machine |
| Mimeograph Machine |
| Thermo-Fax |
| Xerox |

TURN TO FORM II-E-5, page 238 to estimate visual-aid equipment costs.

FORM II-E-5

VISUAL-AID EQUIPMENT

EXAMPLE

| Item | Recommended Quantity | Estimated Quantity Needed | | Unit Cost | | Total Cost |
|---|---|---|---|---|---|---|
| | | | | (Range) | | (Range) |
| 16mm. projector | 1 | 1 | X | 500 to 920 | = | 500 to 920 |
| 8mm. projector | 1 | — | X | — to — | = | — to — |
| Filmstrip projector | 1 | — | X | — to — | = | — to — |
| Slide projector | 1 | 1 | X | 60 to 165 | = | 60 to 165 |
| Opaque projector | 1 | — | X | — to — | = | — to — |
| Tape recorder | 1 | 1 | X | 70 to 270 | = | 70 to 270 |
| 35mm. camera | 1 | 1 | X | 57 to 320 | = | 57 to 320 |
| 35mm. copy stand | 1 | 1 | X | 18 to 50 | = | 18 to 50 |
| Spirit duplicator | 1 | 1 | X | 125 to 290 | = | 125 to 290 |
| Mimeograph machine | 1 | — | X | — to — | = | — to — |
| Thermo-Fax | 1 | 1 | X | 150 to 390 | = | 150 to 390 |
| Xerox | 1 | — | X | — to — | = | — to — |
| | | Visual-Aid Total | | | | 980 to 2,405 (1) |

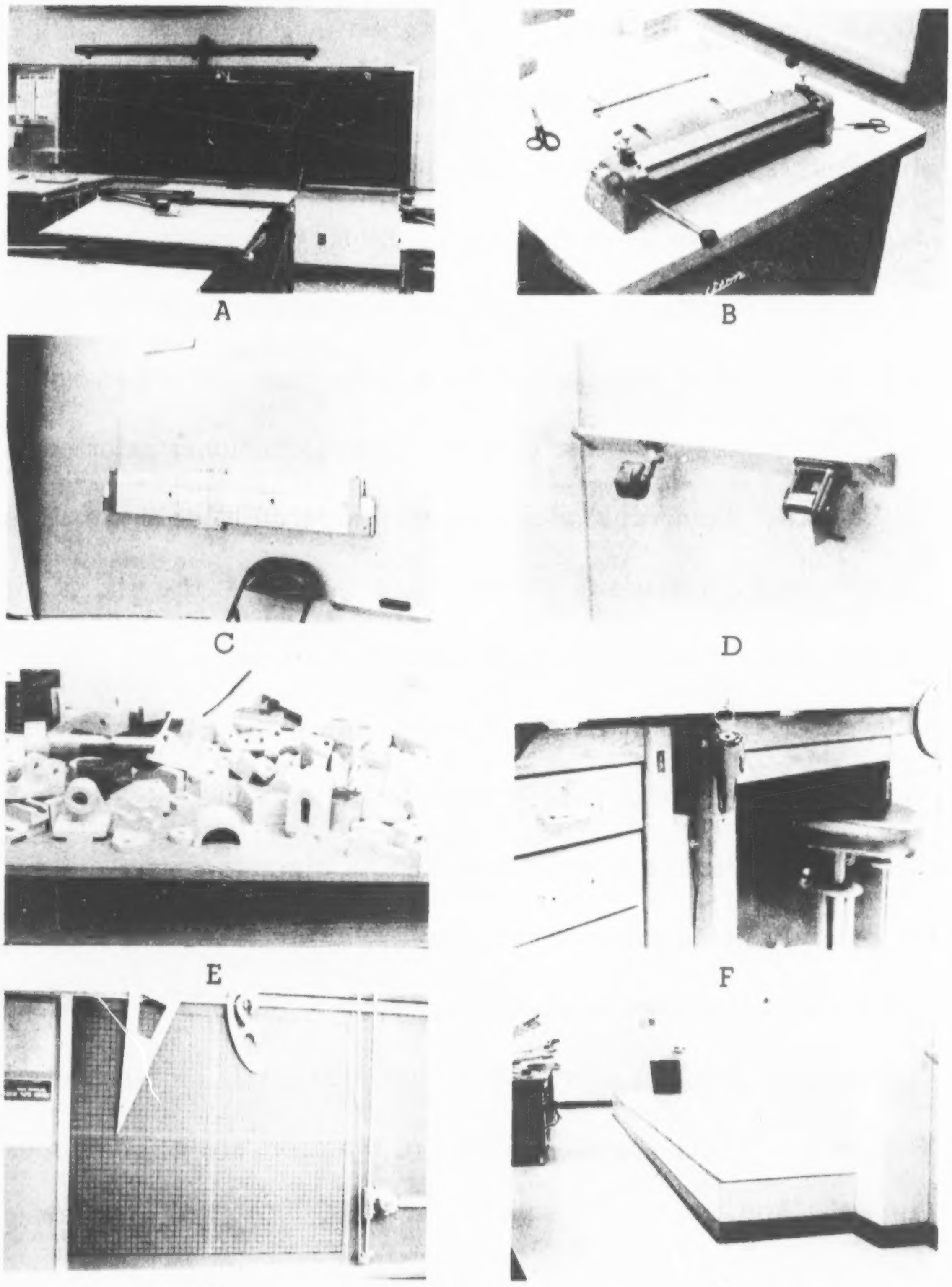
TURN TO PAGE 239 for a discussion of teaching aids.

## Teaching Aids

Plate XIII shows examples of teaching aids used by drafting instructors in Texas junior colleges. A drafting machine similar to the one shown in Picture A was the most common teaching aid found in the colleges. Picture B illustrates a small bar folder that was used to construct models made from discarded metal multilith plates. Picture C shows a large demonstration-size slide rule. Numerous commercially prepared models are illustrated in Picture E. Picture G shows a grid located at the end of the chalkboard. Picture D shows a regular and draftsman pencil sharpener fastened to a chalk tray. An electric eraser mounted between two drafting tables is dipicted in Figure F. The drafting room where Picture F was taken had an electric eraser accessible to every drafting table in the room. Picture H displays a raised platform at the front of the room. Such a platform is recommended, especially in rooms equipped with traditionally high drafting tables and where the dimensions of the room are much deeper than they are wide.

## PLATE XIII

## TEACHING AIDS



A B C D E F G H

Recommendations.--The majority of the drafting people recommended that a drafting room be equipped with a chalkboard drafting machine. Several draftsmen recommended a platform at the front of the room.

## Paper cutter and light table

A paper cutter and a light table are used frequently in a drafting room. Plate XIV shows four different models of paper cutters. The cutter shown in Picture A has a platform to catch the paper after it is cut. The cutter in Picture C includes space for storage of materials. A portable cutter is shown in Picture G.

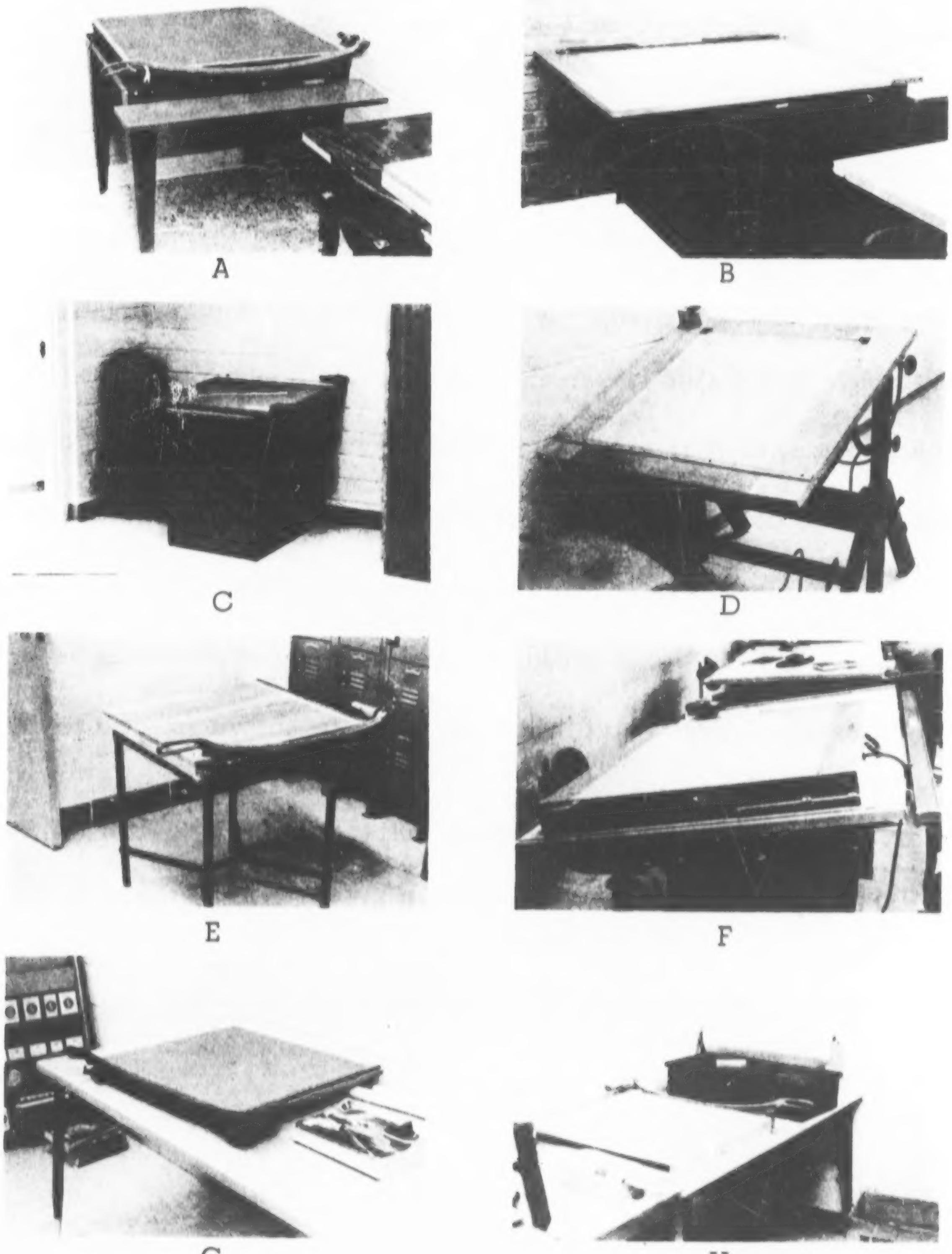
Examples of light tables are shown in Plate XIV. The table illustrated in Picture B could be used by two people because of its size. A small portable light table is shown in Picture F.

Recommendations.--A paper cutter similar to Picture A and a light table that resembles Picture B are recommended.

TURN TO FORM II-E-6 to estimate teaching aid equipment.

## PLATE XIV

## LIGHT TABLES AND PAPER CUTTERS



A B

C D

E F

G H

## FORM II-E-6

## TEACHING AIDS

EXAMPLE

| Item | Recommended Quantity | Estimated Quantity Needed | | Unit Cost | | Total Cost |
|---|---|---|---|---|---|---|
| | | | | (Range) | | (Range) |
| Chalkboard drafting machine | 1 per drafting room | — | X | — to — | = | — to — |
| Paper cutter | 1 | 1 | X | 110 to 150 | = | 110 to 150 |
| Light table | 1 | 1 | X | 170 to 180 | = | 170 to 180 |
| | | Total Teaching Aids | | | | 280 to 330 (1) |

TURN TO FORM II-E-7 to summarize total facilities costs.

FORM II-E-7

FACILITIES COST SUMMARY

EXAMPLE

Advanced Drafting Rooms
Estimated number of rooms: 1 (1A)
Total facilities cost per room
(FORM II-E-2A, line (4) ) 8,195 to 15,649 (1B)
Total facilities cost for advanced drafting
rooms (line (1A) X line (1B) ): 8,195 to 15,649 (1)

Beginning Drafting Rooms
Estimated number of rooms: 1 (2A)
Total facilities cost per room
(FORM II-E-2B, line (4) ) 4,045 to 10,049 (2B)
Total facilities cost for beginning drafting
rooms (line (2A) X line (2B) ): 4,045 to 10,049 (2)

Offices
Estimated number of offices
(Assume one per instructor): 2 (3A)
Total facilities cost per office
(FORM II-E-3, line (3) ): 800 to 1,770 (3B)
Total facilities cost for office
(line (3A) X line (3B) ): 1,600 to 3,540 (3)

Utility-Teacher Preparation Rooms
Estimated number of rooms: 1 (4A)
Total facilities cost per room
(FORM II-E-4, line (1) ): 3,915 to 6,225 (4B)
Total teacher preparation room cost
(line (4A) X line (4B) ): 3,015 to 6,225 (4)

Visual-Aid Equipment (FORM II-E-5, line (1) ): 980 to 2,405 (5)

Teaching Aids (FORM II-E-6, line (1) ): 280 to 330 (6)

TOTAL FACILITIES COST 13115 to 38,198

## Equipment Price List

The following list of price ranges were obtained from catalogues of several suppliers of drafting room equipment. The price ranges have been rounded off for ease in figuring.

| | Price Range |
|---|---|
| Adding machine | \$ 65.00 - \$ 200.00 |
| Bulletin board (Pictures "B", "D", "F", and "H", p. 230 | 15.00 - 35.00 |
| Chairs and stools | |
| Picture "A", p. 204 | 35.00 - 60.00 |
| Picture "E", p. 204 | 15.00 - 25.00 |
| Swivel chair | 20.00 - 95.00 |
| Counters, wooden with cabinets (Pictures "A" and "C", p. 224) | 75.00 - 700.00 |
| Display case (Pictures "E" and "G", p. 230) | 50.00 - 150.00 |
| Drafting machines, table (Plate 1, p. 202) | 50.00 - 200.00 |
| Drafting tables | |
| Picture "A", p. 202 | 450.00 - 700.00 |
| Picture "B", p. 202 | 375.00 - 560.00 |
| Picture "C", p. 202 | 60.00 - 85.00 |
| Picture "D", p. 202 | 100.00 - 160.00 |
| Picture "F", p. 202 | 185.00 - 210.00 |
| Picture "G", p. 202 | 40.00 - 50.00 |
| Picture "H", p. 202 | 180.00 - 210.00 |
| Flat files (5-drawer) Picture "C", p. 214 | 110.00 - 230.00 |

| | |
|---|---|
| File cabinet (4-drawer) | |
| Letter size | 50.00 - 150.00 |
| Legal size | 70.00 - 150.00 |
| Instructor's chair | 40.00 - 120.00 |
| Instructor's desk (Plate III, p. 206) | 100.00 - 260.00 |
| Lead pointers | 2.00 - 4.00 |
| Lettering sets | 35.00 - 120.00 |
| Light table | |
| Picture "B", p. 242 | 175.00 - 200.00 |
| Picture "D", p. 242 | 170.00 - 180.00 |
| Picture "F", p. 242 | 100.00 - 130.00 |
| Map storage cabinet<br>Picture "D", p. 214 | 400.00 - 600.00 |
| Overhead projector (Plate XII, p. 236) | 150.00 - 320.00 |
| Paper cutter | |
| Picture "A", p. 242 | 110.00 - 150.00 |
| Picture "G", p. 242 | 30.00 - 65.00 |
| Pencil sharpener, draftsman | 4.00 - 5.00 |
| Pencil sharpener, regular | 4.00 - 5.00 |
| Projection screen, permanently mounted<br>Picture "B", p. 236 | 40.00 - 65.00 |
| Reproduction Equipment | |
| Printer and developer (Pictures "D", "E", and "F", p. 232 | 550.00 - 1300.00 |
| Large diazo machine (Pictures "A" and "B", p. 232 | 1500.00 - 2500.00 |

| | |
|---|---|
| Sink and cabinet assembly (Plate V, p. 212) | 250.00 - 950.00 |
| Storage cabinet, metal | 60.00 - 100.00 |
| Technical fountain pen sets (3-7 pens/set) | 8.00 - 18.50 |
| Template, assortment | 50.00 - 100.00 |
| Typewriter | 200.00 - 500.00 |
| Visual-aid and reproduction equipment | |
| Projector, 16 mm movie, sound | 500.00 - 920.00 |
| Projector, 8 mm movie | 190.00 - 460.00 |
| Projector, filmstrip | 45.00 - 110.00 |
| Projector, 35 mm slide | 60.00 - 165.00 |
| Projector, opaque | 350.00 - 390.00 |
| Tape recorder | 70.00 - 270.00 |
| Camera, 35 mm | 57.00 - 320.00 |
| Copystand, 35 mm | 18.00 - 50.00 |
| Spirit duplicator | 125.00 - 290.00 |
| Mimeograph machine | 190.00 - 500.00 |
| Thermo-fax | 150.00 - 390.00 |
| Xerox (on lease from Xerox Corporation only; per month minimum plus 1/2¢ to 2 1/2¢ per copy over minimum, depending upon quantity, plus paper and toner.) | 200.00 - 600.00 |